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Assessment of Eastern Georges Bank Haddock for 2008

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ABSTRACT

The total catch of eastern Georges Bank (EGB) haddock in 2007 was 12,680 mt of the 19,000 mt combined Canada/United States of America (USA) quota. The 2007 Canadian catch decreased from 12,051 in 2006 to 11,951 mt while the USA catch increased from 591 mt in 2006 to 729 mt. Canadian scallop fishery discards were estimated at 61 mt and USA groundfish fishery discards were estimated at 482 mt. EGB haddock catches fluctuated around 5,000 mt during 1985-1990. Under restrictive management measures, combined Canada/USA catches declined from over 6,500 mt in 1991 to a low of about 2,200 mt in 1995, averaged about 3,600 mt during 1996-1999 and have increased since then.

Adult population biomass (ages 3+) has steadily increased from near an historical low of 9,000 mt in 1993 to 77,000 mt in 2003. Adult biomass decreased to about 54,000 mt at the beginning of 2005 but subsequently tripled to a record-high 158,100 mt in 2008, higher than the 1931-1955 maximum of about 90,000 mt. The exceptional 2003 year class, estimated at 322.7 million age-1 fish, is the largest observed in the assessment time series (1931-1955 and 1969-2005). The 2001, 2002, 2004 and 2006 year classes, at less than 8 million, and the initial estimate of the 2007 year class at 14 million are below the recent 10 year average (excluding the 2003 year class) of 18 million fish. The 2005 year class, at 27 million, is above the average. The age at full recruitment to the fishery increased in 2003 from Age 4 to Age 5 due to the decrease in size at age. Fishing mortality (ages 4+ for pre 2003 and Age 5+ for 2003 to present) was below $F_{ref} = 0.26$ during 1995 to 2003. The failure of the 2003 year class to recruit as expected to the 2005 and 2006 fishery resulted in fishing mortality in 2005 and 2006 exceeding F_{ref} but F declined to 0.14 in 2007. With expanded age structure, broad spatial distribution and improved recruitment, current resource productivity is high, hindered only by recent reductions in fish weight at age. However, growth in length remains similar to previous years.

Assuming a 2008 catch equal to the 23,000 mt total quota, a combined Canada/USA catch of 33,000 mt in 2009 would result in a neutral risk (50%) that the fishing mortality rate in 2009 will exceed $F_{ref} = 0.26$. A catch of 28,000 mt would result in a low risk (25%) that the fishing mortality rate in 2009 will exceed F_{ref}. However, there is high uncertainty in the partial recruitment estimated for the 2003 year class. Using the observed range of partial recruitment at fishery weight during 1995 to 2006, the 2009 projected catch could vary from 29,000 mt to 36,000 mt.

RÉSUMÉ

Les prises totales d'aiglefin dans l'est du banc Georges en 2007 se sont chiffrées à 12 680 tm, par rapport à un TAC combiné Canada-États-Unis de 19 000 tm. Les prises canadiennes ont diminué, passant de 12 051 tm en 2006 à 11 951 tm en 2007, tandis que celles des États-Unis ont augmenté, passant de 591 tm en 2006 à 729 tm en 2007. Les rejets en provenance de la pêche du pétoncle au Canada et de la pêche du poisson de fond aux États-Unis ont été estimés à 61 tm et 482 tm respectivement. Les fluctuations des prises d'aiglefin dans l'est du banc Georges ont été d'environ 5 000 tm au cours de la période 1985-1990. Des mesures de gestion strictes ont fait baisser les prises combinées du Canada et des États-Unis, qui, après avoir dépassé 6 500 tm en 1991, sont tombées à un creux d'environ 2 200 tm en 1995. Ces prises se sont ensuite situées en moyenne à 3 600 tm de 1996 à 1999 et elles ont augmenté depuis.

La biomasse de la population d'adultes (âges 3+) a constamment augmenté, passant du creux quasi historique de 9 000 tm qu'elle avait connu en 1993 à 77 000 tm en 2003. Elle est tombée à 54 000 tm au début de 2005, mais a triplé par la suite, pour atteindre un pic record de 158 100 tm en 2008, soit un niveau plus élevé que le maximum pour 1931-1955 de 90 000 tm. L'exceptionnelle classe d'âge 2003, estimée à 322,7 millions de sujets d'âge 1, est la plus abondante classe d'âge observée dans les séries chronologiques des évaluations (1931-1955 et 1969-2005). En revanche, les classes d'âge 2001, 2002, 2004 et 2006, chiffrées à moins de 8 millions de sujets, et la classe d'âge 2007, estimée à 14 millions de sujets, se situent sous la moyenne des 10 dernières années, soit 18 millions. La classe d'âge 2005, avec un effectif de 27 millions, est supérieure à la moyenne. L'âge au plein recrutement à la pêche a augmenté en 2003, de l'âge 4 à l'âge 5, en raison de la diminution de la taille selon l'âge. La mortalité par pêche (parmi les âges 4+ avant 2003 et parmi les âges 5+ de 2003 à ce jour) a été inférieure à $F_{réf}$ = 0,26 de 1995 à 2003. Le recrutement attendu de la classe d'âge 2003 à la pêche de 2005 et de 2006 ne s'étant pas produit, la mortalité par pêche de 2005 et de 2006 a été supérieure à $F_{réf}$, mais F a diminué en 2007, à 0,14. En raison de l'élargissement de la structure des âges, de la vaste distribution spatiale et du taux de recrutement plus élevé, la productivité de la ressource est élevée à l'heure actuelle, n'ayant subi comme effet négatif que les réductions récentes du poids selon l'âge. Le taux de croissance selon la longueur demeure toutefois semblable à ce qu'il était les années précédentes.

Si les prises en 2008 étaient égales au TAC de 23 000 tm, des prises combinées Canada/États-Unis de 33 000 tm en 2009 se traduiraient par un risque neutre (50 %) que la mortalité par pêche dépasse $F_{réf}$ = 0,26 en 2009. Des prises de 28 000 tm aboutiraient à un faible risque (25 %) que la mortalité par pêche dépasse $F_{réf}$ en 2009. D'après la fourchette des valeurs observées dans le recrutement partiel selon le poids de 1995 à 2006, les prises projetées pour 2009 pourraient varier entre 29 000 tm et 36 000 tm.

INTRODUCTION

For the purpose of developing a sharing proposal and consistent management by Canada and the United States of America (USA), an agreement was reached that the transboundary management unit for haddock would be limited to the eastern portion of Georges Bank (EGB) (DFO statistical unit areas j and m in NAFO sub-division 5Ze; USA statistical areas 551, 552, 561 and 562 in NAFO sub-division 5Ze; Figure 1; DFO 2002). This assessment applies the approach used by Van Eeckhaute et al. (2007) to Canadian and USA fisheries information updated to 2007. Results from the Fisheries and Oceans Canada (DFO) survey, updated to 2008, and the USA National Marine Fisheries Service (NMFS) surveys in the spring, updated to 2008, and fall, updated to 2007, were incorporated.

FISHERY

Commercial Catches

Canadian

Haddock on Georges Bank have supported a commercial fishery since the early 1920s (Clark et al.1982). Catches from EGB during the 1930s to 1950s ranged between 15,000 mt and 40,000 mt (Figure 2), averaging about 25,000 mt (Schuck 1951, R. Brown pers. com.). Records of catches by unit area for the early 1960s period have not been located, however, based on records for NAFO Subdivision 5Ze, catches from EGB probably attained record high levels of about 60,000 mt during the early 1960s. Catches in the late 1970s and early 1980s (Table 1), ranging up to about 23,000 mt, were associated with good recruitment. Substantial quantities of small fish were discarded in those years (Overholtz et al. 1983). Catches subsequently declined and fluctuated around 5,000 mt during the mid to late 1980s. Under restrictive management measures (Table 2), combined Canada/USA catches declined from over 6,500 mt in 1991 to a low of about 2,100 mt in 1995, fluctuated between about 3,000 mt and 4,000 mt until 1999 and increased to 15,112 mt in 2005 (Figure 3). In 2007, the Canadian catch was 11,951 mt and the USA catch was 729 mt with quotas of 12,730 mt for Canada and 6,270 mt for the USA for a total combined catch of 12,680 mt (combined quota was 19,000 mt).

Some elements of the management measures used on EGB are described in Table 2. Quotas are the principal means used to regulate the Canadian groundfish fisheries on Georges Bank. Quota regulation requires effective monitoring of fishery catch. Weights of all Canadian landings since 1992 were monitored at dockside. Canadian catches since 1995 have usually been below the quota due to closure of some fleet sectors when the cod quotas were reached. At-sea observers monitored 98% of otter trawl and 8% of longline landings by weight in 2007. Discarding and misreporting of haddock by the groundfish fishery have been negligible since 1992.

Between 1994 and 2004, the Canadian fishery for groundfish was not permitted from 1 January to 30 May. In 2005, increasing haddock abundance led to an exploratory Canadian groundfish fishery in January and February that was continued in 2006 and 2007. So as not to adversely affect the rebuilding of cod on EGB, the exploratory winter fishery was closed (February 15 in 2007) when it was determined that cod were actively spawning, i.e. when 30% of cod were in the spawning or post-spawning stages.

In recent years, the Canadian fishery has been conducted primarily by vessels using otter trawls and longlines with some handlines and gillnets. In 2007, 99% of the catch was taken by tonnage

class 1, 2 and 3 (less than 150 tons) vessels, corresponding roughly to vessels less than 65 ft in overall length. Otter trawls took 84% of the haddock and longliners took 16% (Table 3). The highest monthly catches in 2007 occurred in July followed by August, September and June (26%, 21%, 16% and 12%, respectively) (Table 4, Figure 4). The winter fishery accounted for 13% of the landings.

Canadian landings until 1995 include those catches reported by the scallop fishery, but, since 1996, this fishery has been prohibited from landing haddock and this species is discarded. Landings of haddock by the scallop fleet have been low (Table 3) with a maximum of 38 mt reported in 1987. Discards of haddock ranged between 29 and 186 mt since 1969 (Van Eeckhaute et al. 2005, Gavaris et al. 2007) and were estimated at 61 mt in 2007 (Table 1; Jonsen et al. 2008).

USA

Management measures for the USA fishery have been primarily effort based since 1994; however, in 2004, quota management was introduced to regulate the USA groundfish fishery (Table 2). The USA portion of the EGB management area was closed to groundfish vessels from June 20 to Oct 19 in 2007 due to the cod catch nearing the quota. Landings by month and gear/tonnage class for 1969 to 1993 are slightly different than what was reported in previous assessments as they were recalculated using a standard algorithm for estimating landings by statistical area (Palmer 2008). USA landings of EGB haddock in 2007 were derived from mandatory fishing vessel logbooks and dealer reports. A new system was used to allocate landings for 1994-2007 and is described in (Wigley et al. 2008).

Groundfish fishery discards were estimated from observer samples by taking the quarterly ratio of kept to discarded haddock. Each quarterly ratio was then raised by total landed haddock per quarter. This differs from the method used to estimate discards for the assessment of Georges Bank as a whole, where the ratio of kept haddock to discards of all species was used (see Wigley et al. 2007 for ratio estimator details). Due to the low number of observed trips to EGB, and the fact that the observed trips only span the years 1989-present, the existing discard estimation (ratio of kept:discarded haddock) was applied to maintain consistency with the existing time series of discards in the assessment. In the future, it would be worthwhile to explore whether the two methods produce similar scales of discard estimates.

USA catches of EGB haddock increased in 2007 to 729 mt compared to the 2006 catch of 591 mt. The 2007 USA catch quota was 6,270 mt (Table 1); as in 2005 and 2006, the 2007 catch was constrained by the low cod quota. Landings accounted for 247 mt. The majority of USA landings occurred in quarter 2 (72%) and quarter 4 (25%). Landings were very low for quarters 1 and 3 (Table 5). As in other years, the otter trawl gear accounted for the majority of the USA landings (230 mt). The contribution by other gear (16 mt) was 6% (Table 6).

USA discards from the otter trawl fishery increased from 146 mt in 2006 to 482 mt in 2007. Discards from this fleet had been relatively low in recent years due to high trip limits and larger trawl mesh size but, in 2007, 66% (by weight) of the haddock catch was discarded, an increase from 2004, 2005 and 2006 when discards accounted for 8%, 10% and 25%, respectively, of the USA catch. Most of the discards, 428 mt (89%), occurred in quarter 4 (Table 7). To mitigate the discarding of haddock, the minimum legal size was decreased in August 2007 from 48.2 cm (19") to 45.7 cm (18"). The discards from the scallop fleet were not available but have been negligible in the past.

Size and Age Composition

Canadian

The size and age composition of haddock in the 2007 Canadian groundfish fishery was characterized using port and at-sea samples from all principal gears and seasons (quarters) (Table 8). For trips that were sampled by both at-sea observers and port samples, the length frequencies were combined to ensure that samples were used in a consistent manner. The size composition of haddock discards in the 2007 Canadian scallop fishery was characterized by quarter using length samples obtained from 14 observed scallop trips (Table 8). The 2007 DFO survey ages, augmented with port samples, were applied to the first quarter length composition and fishery age samples for quarters 2, 3 and 4 were applied to the corresponding length compositions for both the groundfish fishery and discards.

The modal length of landings in the Canadian fisheries was 46.5 cm for otter trawlers and longliners (Figure 5). The winter fishery caught larger fish, with a mode at 52.5 cm (Figure 6). Gill-netters caught few haddock. The percentage of haddock below 43 cm decreased slightly from 10% in 2006 to 9% in 2007. The scallop dredge discards mode was 42.5 cm.

USA

USA landings of EGB haddock are divided into "large" and "scrod" market categories for sale purposes. Landings of large haddock totaled 47 mt and scrod haddock totaled 199 mt in 2007 (Table 7). Length samplings for USA EGB landings in 2007 were limited and were available only for quarters 1, 2 and 4. All market/quarter categories, except for "unclassified", were augmented with lengths from adjacent unit areas 522 (5Zh) and 525 (5Zn). Age sampling was similarly distributed with a total of 235 ages. There was only 1 age sample of 50 fish available for the "large" category so the landings for large could only be estimated at an annual level. There were a few more samples for scrod (3 samples for each half-year) so the scrod landings at age could be estimated semi-annually but not quarterly. Due to the low level of sampling, and with the majority of the landings in quarter 2, an annual age-length key was applied to the USA landings and the resultant landings at age were assigned to quarter 2 (Table 9).

USA fishermen are required to discard haddock under the legal size limit. US discards at age of Georges Bank haddock for calendar year 2007 in statistical areas 551, 552, 561 and 562 (Eastern Georges Bank, EGB) were estimated quarterly from at-sea observer data. Due to low sampling, length frequencies in the EGB were augmented with samples from the adjacent areas of 522 and 525. As most of the discarding was due to the otter trawl fleet, length samples from remaining gears were scant (hook, gillnet, and 'other'). Available length frequencies were compared by gear, and both the range of observations, and the modal length, appeared similar. Therefore, length samples were combined across gears. The resulting combined length frequencies by quarter were converted to discarded number at age (Table 9) by applying the spring (quarters 1 and 2) or fall (quarters 3 and 4) NMFS bottom trawl survey age length key. Discarded numbers at age were converted to discarded weight at age by quarter by taking the product of the number at length by the weight at length by the age length key by quarter. Total estimated US discards on EGB in calendar year 2007 were 482 mt. The total number of observed trips decreased to 17 in 2007, down from 54 observed trips on EGB in 2006.

The length composition of USA landings were bimodal at 48.5 cm with a smaller mode at 56 cm. The discards mode was at 46.5 cm (Figure 7).

Ages of survey and commercial-caught haddock were separately assigned by the DFO and the NMFS age readers, L. Van Eeckhaute and S. Sutherland, respectively. Inter-reader agreement testing between the NMFS and DFO labs was completed and intra-reader testing was undertaken at the NMFS lab. High agreement was attained, indicating that age determinations at both labs continue to be reliable (Table 10, http://www.nefsc.noaa.gov/fbi/QA-QC/age-results.html). Age reader agreement was judged to be satisfactory for estimating catch at age.

The 2007 Canadian and USA landings and discards at age estimates by quarter (Table 9) were summed to obtain the combined quarterly and annual catch at age (Table 11 and Figure 8) and appended to the 1969-2006 catch at age data (Van Eeckhaute et al. 2007). The age composition of the catch projection made in 2006 for 2007 agrees well with the observed (Figure 9). Average Canadian fishery weights and lengths at age are summarized in tables 12 and 13, and Figure 10. The 2003 year class (Age 4) dominated the fishery in 2007. USA discards represented 73% by numbers of the USA catch, but only 5% by numbers of the combined Can/USA catch. Most of the USA discards were Age 4, i.e., 2003 year class.

The dominant age group in the fishery has increased from ages 2 and 3 during earlier periods to Age 4 in 1995 to 2004 due primarily to a change in mesh type and an increase in mesh size (Table 2). The 2005 to 2007 age composition reflects its domination by the 2000 and 2003 year classes. The age composition during the 1969 to 1974 period was atypical since it was dominated by the outstanding 1962 and 1963 year classes which continued to contribute substantially at ages 6 and older (Figure 11).

ABUNDANCE INDICES

Research Surveys

Surveys of Georges Bank have been conducted by DFO each year (February/March) since 1986 and by NMFS each fall (October/November) since 1963 and each spring (April) since 1968. All surveys use a stratified random design (figures 12 and 13). For the NMFS surveys, two vessels have been employed and there was a change in the trawl door type in 1985. Vessel and door type conversion factors (Table 14), derived experimentally from comparative fishing, have been applied to the survey results to make the series consistent (Forrester et al. 1997). Additionally, two different trawl nets have been used on the NMFS spring survey, a modified Yankee 41 during 1973-81 and a Yankee 36 in other years, but no conversion factors are available for haddock.

The *Alfred Needler* is the standard vessel used for the DFO Georges Bank survey, but, due to unavailability of the *Needler*, the *Wilfred Templeman*, a sister ship to the *Needler*, has been used in several years, 1993, 2004, 2007 and again in 2008. No conversion factors are available for the *Templeman*, however, this vessel is considered to be similar in fishing strength to the *Needler*. In 2008, the DFO survey was delayed and took place in March over a 3 week period.

The spatial distribution of catches by age group (1, 2, and 3+ for spring and 0, 1 and 2+ for fall) for the most recent surveys is shown in comparison to the average distribution over the previous 10 year period (figures 14, 15 and 16). Ages 2+ in the NMFS 2007 fall survey were found on the northern edge in large numbers similar to the 10-year average distribution. The 2008 DFO survey found adult fish (ages 3+) abundant and widely distributed on the Canadian side of the bank with some large catches in 5Zm on the USA side near the Canada/USA border. A month later, during the NMFS spring survey, adult fish were found in large quantities on the US side as well as the Canadian side, a distribution pattern which has been persistent from year to year.

Catches of the 2006 year class were low for all three surveys. Catches of the 2007 year class were also low and were more abundant on the southern part of the bank.

Age-specific, swept area abundance indices show that the three surveys are consistent and track year class strengths well (tables 15, 16 and 17; Figure 17). Some year effects are evident. For example, low spring catches occurred in both the 1997 DFO and NMFS surveys. Survey adult biomass indices (ages 2-8 in fall; 3-8 in spring) peaked during the early 1960s (Figure 18). After declining to a record low in the early 1970s, they peaked again in the late 1970s, though at a lower level, and again during the mid to late 1980s at about half the level of the 1970s peak. Adult biomass generally increased during the 1990s and 2000s. Since about 2003, the adult biomass indices have seen significant fluctuation with a large decrease in 2008 for the NMFS spring survey, an increase in the 2007 NMFS fall survey and the 2008 DFO survey.

All three survey series indicate that the 2003 year class is one of the strongest on record with the Age 5 indices for the spring surveys and the Age 4 index for the fall survey the highest for those series for those ages. The three new survey observations for the 2006 year class are all lower than the previous year's values (Figure 19). First indications for the 2007 year class indicate that it may be better than the 2001, 2002 and 2006 year classes.

GROWTH

Canadian fishery weights at age (Table 12, Figure 10) in 2007 increased for ages 1 to 4, but, decreased for ages 5 to 8. In 2008, DFO survey weights at age (Table 18 and Figure 10) and lengths at age (Table 19 and Figure 20) increased for ages 1 to 4, and Age 7, interrupting a downward trend that started after the mid-1990s for the older ages and around 2001 for the younger ages. Weights for ages 5 and 8, the dominant year classes, decreased. Average size at age has declined substantially so that haddock of Age 3 and older are now at or smaller than the size that the next younger age group was in previous years before the declines occurred. However, the 2007 year class average survey weight and length at Age 1 are at the level that was seen in earlier years.

Weights at age from the DFO survey are considered beginning of year population weights and are calculated using the method described in Gavaris and Van Eeckhaute (1998) in which weights observed from the survey are weighted by population numbers at length and age. Fishery weights are derived from the lengths using a length-weight relationship (Waiwood and Neilson 1985).

HARVEST STRATEGY

The Transboundary Management Guidance Committee (TMGC 2003) has adopted a strategy to maintain a low to neutral risk of exceeding the fishing mortality limit reference, F_{ref} = 0.26. When stock conditions are poor, fishing mortality rates should be further reduced to promote rebuilding.

ESTIMATION OF STOCK PARAMETERS

Calibration of Virtual Population Analysis (VPA)

Tuned virtual population analysis was used to estimate stock parameters. The adaptive framework, ADAPT, (Gavaris 1988) was used to calibrate the virtual population analysis with the research survey data. Details of the model formulations and model assumptions can be found in Gavaris and Van Eeckhaute (1998) with the following modifications: 1) an annual catch at age instead of a quarterly catch at age, 2) revised survey timing, and 3) change in ages used to estimate oldest age F. The survey timing was revised from what was used in previous assessments to include recent years in the calculation as follows: DFO spring from 0.16 to 0.17, NMFS spring from 0.29 to 0.28 and the NMFS fall survey from 0.69 to 0.79. The large fall survey change was mainly due to an error in the previous calculation. The effects of these two changes on population numbers and 4+ F are negligible and are illustrated in Appendix A, figures A1 to A4. An increase in the age at full recruitment to the fishery was observed from 2003 onward which prompted a change in the ages used to calculate F on the oldest age (Age 8). Figure 21 illustrates the relationship between Age 4 and Age 5 within the same year class for numbers caught and for fishing mortality. Both catch and F show a decrease in Age 4 catch and F relative to Age 5 for 2003 to 2006. Therefore, oldest age F for 2003 to 2007 was calculated using the average weighted F on ages 5 to 7 instead of ages 4 to 7, as was done in previous assessments.

The VPA was based on an annual catch at age, $C_{a,t}$ for ages a = 0, 1, 2...8, 9+, and time t = 1969, 1970...2007 where t represents the beginning of the time interval during which the catch was taken. Catch at age 0 (i.e., discards) was included in the catch at age. The population was calculated to the beginning of 2008. The VPA was calibrated to bottom trawl survey abundance indices, $I_{s,a,t}$ for

s = DFO, ages a = 1, 2, 3...8, time t = 1986.17, 1987.17... 2007.17, 2008.00

s = NMFS spring (Yankee 36), ages a = 1, 2, 3...8, time t = 1969.28 1970.28, ...2007.28, 2008.00

s = NMFS spring (Yankee 41), ages a = 1, 2, 3...8, time t = 1973.28, 1974.28...1981.28

s = NMFS fall, ages a = 0, 1, 2...5, time t = 1969.79, 1970.79...2007.79. Since the population is calculated to beginning year 2008, the NMFS and DFO spring surveys in 2008 were designated as occurring at time 2008.00. Other details of the tuning setup were the same as those used in the previous assessments and can be found in Van Eeckhaute et al. 2007.

Statistical properties of estimators were determined using conditional non-parametric bootstrapping of model residuals (Efron and Tibshirani 1993, Gavaris and Van Eeckhaute 1998). Population abundance estimates at ages 1 and 2 exhibited a large relative error of 59% and 41%, respectively, and a large relative bias at Age 1 of 13%, while the relative error for other ages was between 26% and 32% with a relative bias between 1% and 6% (Table 20). While trends in the three surveys are generally consistent, the survey indices exhibit high variability and the average magnitude of residuals is large relative to other assessments. Although several large residuals were apparent, these do not appear to have a substantial impact on estimates of current abundance (figures 22-26). Some patterns in the residuals (by cohort and by age) suggest year class and/or year effects.

Retrospective Analysis

Retrospective analyses were used to detect any patterns to consistently overestimate or underestimate fishing mortality, biomass and recruitment relative to the terminal year estimates. This stock assessment does not display a retrospective pattern. While recruitment estimates may sometimes change substantially when more data becomes available, e.g., the 1998, 2000 and 2003 year classes, successive estimates of year class abundance at age do not display any persistent tendency to be higher or lower (Figure 27). Similarly, retrospective analysis showed no persistent patterns in the estimates of adult biomass (ages 3-8) or fishing mortality (ages 4-8 weighted by population numbers) (Figure 28).

STATE OF RESOURCE

The state of the resource was based on results from an age structured analytical assessment (VPA) that used fishery catch statistics and sampling for size and age composition of the catch (landings plus discards) for 1969 to 2007. The VPA was calibrated to trends in abundance from three bottom trawl survey series; NMFS spring, NMFS fall and DFO. For each cohort, the terminal population abundance estimates from ADAPT were adjusted for bias estimated from the bootstrap, and used to construct the history of stock status (tables 21, 22 and 23). This approach for bias adjustment was considered preferable to using potentially biased point estimates of stock parameters (O'Boyle 1998). The weights at age from the DFO survey (Table 18) were used to calculate beginning of year population biomass (Table 23). A weight of 2.4 kg, which was midway between the ages 6 and 8 weight for that cohort, was used for Age 7 in 1995 as no data were available for that age group. The 1986-95 average weight at each age was used for 1969-85.

Data to approximate the age composition of the catch from unit areas 5Zj and 5Zm during 1931 to 1955 were used to reconstruct a population analysis of EGB that was suitable for comparison of productivity.

The adult (ages 3+) biomass trend compared favorably with the survey adult biomass trends (scaled with catchabilities) (Figure 29). Adult biomass increased to 38,000 mt during the late 1970s and early 1980s due to recruitment of the strong 1975 and 1978 year classes whose abundances were estimated to be above 50 million age-1 fish each (Figure 30). However, adult biomass declined rapidly in the early 1980s as subsequent recruitment was poor and these two cohorts were fished intensely at ages 2 and 3. Improved recruitment in the 1990s and the strong 2000 year class (77 million at Age 1), lower exploitation, and reduced capture of small fish in the fisheries allowed the biomass to increase from near an historical low of 9,000 mt in 1993 to 77,100 mt in 2003. Adult biomass decreased to 54,000 mt in 2005 but subsequently increased to 158,100 mt (80% Confidence Interval: 122,300 – 201,100 mt, Figure 31) in 2008; higher than the 1931-1955 maximum adult biomass of about 90,000 mt. The tripling of the biomass after 2005 was due to the exceptional 2003 year class, estimated at 322.7 million Age 1 fish, the largest in the assessment time series (1931-1955 and 1969-2007). In contrast, the 2001, 2002, 2004 and 2006 year classes, at less than 8 million fish, are below the 18 million average of the 10 most recent year classes (excluding the 2003 year class). The 2005 year class (26.9 million Age 1 fish) is well above the 10 year average. The 2007 year class presently appears to be below-average at 13.8 million fish at Age 1.

Fishing mortality (population weighted average of fully recruited ages) fluctuated between 0.2 and 0.4 during the 1980s, and markedly increased in 1992 and 1993 to about 0.6, the highest observed (Table 22, Figure 32). From 2003 onwards, the age at full recruitment into the fishery

has been at Age 5 (rather than Age 4 as in previous years) due to a decline in size at age of haddock. Fishing mortality (ages 4+ for pre-2003 and ages 5+ for 2003 onwards) was below F_{ref} = 0.26 during 1995 to 2003, above F_{ref} during 2004 to 2006, but in 2007 declined to 0.14 (80% Confidence Interval: 0.11 – 0.18, Figure 31). The determination of F_{ref} was based on analyses that assumed full recruitment to the fishery for ages 4 and older.

The partial recruitment at age for EGB haddock has decreased in recent years (Table 24 and 25; Figure 33) and, consequently, fishing mortality based on ages 5+, as fully recruited, has been consistently higher than F for ages 4+ since 2003 (Figure 32). This is most noticeable for 2004 and 2007, years when the large 2000 and 2003 year classes were Age 4 and had a large effect on the 4+ F. Lower weights at age have resulted in a reduced partial recruitment so that Age 4 is now no longer fully recruited to the fishery. Therefore, partial recruitment estimates for ages 1 to 4 for recent years are more appropriately normalized on ages 5-8 (Table 25). Due to the magnitude of the 2003 year class, the partial recruitment pattern used for this year class will have a significant impact on the estimates of the magnitude and composition of future catches.

Gains in fishable biomass may be partitioned into those associated with somatic growth of haddock which have previously recruited to the fishery, and those associated with new recruitment to the fishery (Rivard 1980). We used Age 2 as the age of first recruitment to the fishery. This choice facilitated comparisons with historic stock productivity but may be less representative of the current fishery selectivity. Since 1993, except for 1996, 2001, 2003 and 2004, surplus production (biomass gains from growth and from recruitment, decremented by losses due to natural deaths) has exceeded fishery harvest yields, resulting in net population biomass increases (Figure 34). Growth of fish is the dominant component of the biomass gain but recruitment accounts for significant portions when stronger year classes enter the population, e.g. the 2000 year class in 2002 and the 2003 year class in 2005 (Figure 35). The biomass contributed by the 2003 year class, both when it recruited at Age 2 and through growth during that year was greater than that of any other previous cohort since 1969.

PRODUCTIVITY

Recruitment, as well as age structure, spatial distribution and fish growth reflect changes in the productive potential.

Recruitment, while highly variable, has generally been higher when adult biomass has been above 40,000 mt (Figure 36). Since 1969, only the 1975, 1978, 2000 and 2003 year classes have been above the average abundance of year classes observed during the period 1931-55. The recruits per adult biomass ratio was generally low during the 1980s but higher during the 1990s, comparable to that in the 1931-1955 period (Figure 37), when the 3+ biomass was above 40,000 mt. Since 2001, with the exception of 2003 and 2005, recruits per spawner have again been low.

In both absolute numbers and percent composition, the population age structure displays a broad representation of age groups (Figure 38), reflecting improving recruitment and lower exploitation, particularly at younger ages, since 1995.

The spatial distribution patterns observed during the most recent bottom trawl surveys were similar to the average patterns over the previous ten years. Consistent with the pattern observed for previous exceptional year classes, the 2003 year class, the main component of the 3+ age group, was widely distributed throughout the survey area (figures 14, 15 and 16).

DFO survey average weights at length, used to reflect fish condition, exhibit a declining trend since the late 1990s (Figure 39). A reduction was again observed during 2007. Both length and weight at age have generally declined since about 2000. While size at age increased in 2008 for the younger age groups, weights remained below the 1991 to 2000 average (Table 18). The size at age for the 2003 year class is smaller than previous year classes, but its rate of growth at length is similar to previous year classes (Figure 40).

In summary, with expanded age structure, broad spatial distribution and improved recruitment, resource productivity is currently high, hindered only by the recent reductions in fish size at age.

OUTLOOK

This outlook is provided in terms of consequences with respect to the harvest reference points for alternative catch quotas in 2009. Uncertainty about standing stock generates uncertainty in forecast results which is expressed here as the risk of exceeding F_{ref}=0.26. The risk calculations assist in evaluating the consequences of alternative catch quotas by providing a general measure of the uncertainties. However, they are dependent on the data and model assumptions and do not include uncertainty due to variations in weight at age, partial recruitment to the fishery, natural mortality, systematic errors in data reporting or the possibility that the model may not reflect stock dynamics closely enough. To characterize the dependence of the projection results on the fishery partial recruitment for the 2003 year class, a sensitivity analysis was performed to augment the risk analysis.

For the projection and risk assessment, for values which did not involve the 2003 year class the following inputs were used. The average DFO survey weights at age for the three most recent years (Table 18) were used for beginning year population weights. Average fishery weights at age for the three most recent years (Table 12) were used for fishery weights. For the partial recruitment, the average fishery partial recruitment for the most recent five years was used (Table 29).

As in the previous assessment for this stock, the 2003 year class will comprise a large portion of the catch for the projected year, 2009. Predictions of weights at age and partial recruitment for this year class used for input into the risk assessment and projection are very influential. Inputs for population and fishery weights for the 2003 year class were derived by accounting for recent trends in reduced growth rate as demonstrated by the 1998, 1999 and 2000 year classes (Figure 41), as was done for the 2006 and 2007 assessments (Van Eeckhaute and Brodziak 2006, Van Eeckhaute et al. 2007). Data points at younger ages were excluded as the addition of these points changed the functional relationship from linear to curvilinear. The predicted growth rate at length was applied to the 2008 DFO survey average length for the 2003 year class (45.7 cm at Age 5) to obtain the beginning of year length at Age 6, i.e. $L6=L5 \times e^{growth\ rate}$, and then sequentially, at Age 7 using the growth rate predicted for the length at Age 6 (Table 26). Average fishery lengths were determined from the relationship between beginning year length (from the DFO survey) and the fishery length in the same year using data from 1995 to 2006, when the Canadian mobile gear fishery was using square mesh after having use diamond mesh previously. (Figure 42). The resulting 2003 year class predicted lengths used for the population and fishery are compared to other year classes in Figure 43. The length estimates were then converted to weights using the length weight relationship used to convert the Canadian fishery lengths to weights (Waiwood and Neilson 1985). Beginning of year weights at age were reduced by 10% to account for the reduction in observed weights relative to those derived from the length weight relationship (Table 27). Weights at age for the fishery, derived from the length

weight relationship, were considered appropriate as this relationship is based on fishery data (Table 28).

The relationship between partial recruitment values and fishery weights, which reflect fishery lengths, was used to determine partial recruitment values. The Canadian groundfish fishery switched from diamond mesh to square mesh around 1995 so data from 1995 to 2007 were used to determine this relationship (Figure 44). A drop in Age 4 partial recruitment compared to Age 5 is observed after 2002 (Table 24). Therefore, the 1995 to 2002 partial recruitment values were based on ages 4-8 as fully recruited while the 2003 to 2007 values were based on ages 5-8. Values of 0.58 for Age 5 in 2008 and 0.83 for Age 6 in 2009 were judged to be appropriate for the 2003 year class for the catch projection.

Stock size estimates at the beginning of 2008 were used to start the forecasts. Abundances of the 2008 and 2009 year classes were assumed to be 20 million at Age 1, which is near the previous 10-year average (2003 year class excluded). Natural mortality was assumed to be 0.2.

A risk assessment was conducted to beginning year 2010 which incorporated these patterns in growth and partial recruitment (Table 29). Assuming a 2008 catch equal to the 23,000 mt total quota, a combined Canada/USA catch of 33,000 mt in 2009 results in a neutral risk (50%) that the 2009 fishing mortality rate would exceed $F_{ref} = 0.26$ (Figure 45) and adult biomass is projected to be 131,000 mt at the beginning of 2010 (Table 30). A catch of 28,000 mt in 2009 results in a low risk (25%) that the 2009 fishing mortality rate will exceed F_{ref}. The 2003 year class is expected to constitute 87% of the 2009 catch biomass. Ages 7+ are expected to account for 5% of the catch biomass, 4% by numbers.

SPECIAL CONSIDERATIONS

While best judgment was used to determine the fishery partial recruitments for the reduced weight of the 2003 year class, the risk analysis does not capture the extent of uncertainty of the consequences for various catch levels. Using the observed range of partial recruitment at weight during 1995 to 2007, (Low=0.4 - 0.7, High= 0.7 – 0.9), the 2009 projected catch could vary from 29,000 mt to 36,000 mt. If the realized partial recruitment is near the higher end of the observed partial recruitment range (and the 2009 TAC is actually achieved), the fishery may possibly forgo available yield; if the realized partial recruitment is at the lower end, the 5+ fishing mortality could be higher than F_{ref}.

The size at age for the 2003 year class is smaller than previous year classes, but, its rate of growth at length is similar to previous year classes. Consequently, current indications suggest that the 2003 cohort could eventually achieve a typical adult size. Size at Age 1 of the 2007 year class is similar to year classes before 2000.

Cod and haddock are often caught together in groundfish fisheries, although their catchabilities to the fisheries differ and they are not necessarily caught in proportion to their relative abundance. With current fishing practices and catch ratios, the achievement of rebuilding objectives for cod may constrain the harvesting of haddock. Modifications to fishing gear and practices, with enhanced monitoring, may mitigate these concerns.

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Table 1. Nominal catches (mt) of haddock from eastern Georges Bank (EGB) during 1969-2007. For "Other" it was assumed that 40% of the total 5Z catch was in EGB.

	Landings			Discards		Total			Quotas	
Year	Canada	USA	Other	Canada	USA	Canada	USA	Catch	Canadian	USA
1969	3941	6622	695	123		4064	6622	11381		
1970	1970	3153	357	116		2086	3153	5596		
1971	1610	3534	770	111		1721	3534	6025		
1972	609	1551	502	133		742	1551	2795		
1973	1565	1396	396	98		1663	1396	3455		
1974	462	955	573	160	757	622	1712	2907		
1975	1353	1705	29	186		1539	1705	3273		
1976	1355	973	24	160		1515	973	2512		
1977	2871	2429		151	2966	3022	5395	8417		
1978	9968	4724		177	1556	10145	6280	16425		
1979	5080	5211		186		5266	5211	10477		
1980	10017	5615		151	7561	10168	13176	23344		
1981	5658	9077		177		5835	9077	14912		
1982	4872	6280		130		5002	6280	11282		
1983	3208	4454		119		3327	4454	7781		
1984	1463	5121		124		1587	5121	6708		
1985	3484	1683		186		3670	1683	5353		
1986	3415	2200		92		3507	2200	5707		
1987	4703	1418		138		4841	1418	6259		
1988	4046	1693		151		4197	1693	5890		
1989	3060	787		138		3198	787	3985		
1990	3340	1189		128		3468	1189	4657		
1991	5456	949		117		5573	949	6522		
1992	4058	1629		130		4188	1629	5817	5000	
1993	3727	421		114		3841	421	4262	5000	
1994	2411	33		114	258	2525	291	2816	3000	
1995	2065	22		69	25	2134	47	2181	2500	
1996	3663	36		52	41	3715	77	3792	4500	
1997	2749	48		60	63	2809	111	2919	3200	
1998	3371	311		102	14	3473	325	3798	3900	
1999	3681	355		49		3729	355	4084	3900	
2000	5402	187		29		5431	187	5618	5400	
2001	6774	604		39	40	6813	644	7457	6989	
2002	6488	914		29	35	6517	949	7465	6740	
2003	6775	1564		98	63	6874	1627	8500	6933	
2004	9745	1796		93	156	9838	1952	11790	9900	5100
2005	14484	512		52	57	14536	569	15112	15410	7590
2006	11984	445		67	146	12051	591	12642	14520	7480
2007	11890	247		61	482	11951	729	12680	12730	6270

[1] 1895 mt excluded because of suspected area misreporting.

Table 2. Regulatory measures implemented for the 5Z and eastern Georges Bank (EGB) fishery management units by the United States (USA) and Canada, respectively, from 1977, when jurisdiction was extended to 200 miles for coastal states, to the present.

	USA	Canada
1977-82	Mesh size of 5 1/8" (140 mm), seasonal spawning closures, quotas and trip limits.	
1982-85	All catch controls eliminated, retained closed area and mesh size regulations, implemented minimum landings size (43 cm).	First 5Ze assessment in 1983.
Oct.1984	Implementation of the 'Hague' line, the boundary between Canada and the USA.	
1985	5 ½" mesh size, Areas 1 and 2 closed February-May.	
1989		Combined cod-haddock-pollock quota for 4X-5Zc
1990		EGB adopted as management unit. For mobile gear (MG) < 65 ft. – trip limits with a 30% by-catch of haddock to a maximum of 8 trips of 35,000 lbs per trip between June 1 and Oct. 31 and 130 mm square mesh required. Fixed gear required to use large hooks until June
1991	Established overfishing definitions for haddock.	MG < 65 ft similar to 1990 but mesh size increased to 145 mm diamond.
1992		Introduction of Individual Transferable Quotas (ITQ) and dockside monitoring. Total allowable catch (TAC) = 5000 mt.
1993	Area 2 closure in effect from Jan 1-June30.	Otter trawl (OT) fishery permitted to operate in Jan. and Feb. Increase in use of square mesh. TAC = 5000 mt.
1994	Jan.: Expanded Area 2 closure to include June and increased extent of area. Area 1 closure not in effect. 500 lb trip limit. Catch data obtained from mandatory log books combined with dealer reports (replaces interview system). May: 6" mesh restriction. Dec.: Area 1,2 closed year-round.	Spawning closure extended to Jan. 1 to May 31. Fixed gear vessels must choose between 5Z or 4X for the period of June to September. Small fish protocol. Increased at sea monitoring. OT > 65 could not begin fishing until July 1. Predominantly square mesh by end of year. TAC = 3000 mt.
1995		All OT vessels using square mesh. Fixed gear vessels with a history since 1990 of 25t or more for 3 years of cod, haddock, pollock, hake or cusk combined can participate in 5Z fishery. ITQ vessel require at least 2t of cod and 8t of haddock quota to fish Georges. TAC = 2500 mt. Restrictions on catching of cod and haddock under 43 cm (small fish protocol).
1996	July: Additional Days-at-Sea restrictions, trip limit raised to 1000 lbs.	Fixed gear history requirement dropped. TAC = 4500 mt.
1997	May: Additional scheduled Days-at-sea restrictions. September: Trip limit raised to 1000 lbs/day,	Vessels over 65 ft operated on enterprise allocations, otter trawlers under 65 ft on individual quotas, fixed gear vessels 45-65 ft

	USA	Canada
	maximum of 10,000 lbs/trip.	on self-administered individual quotas and fixed gear vessels under 45 ft on community quotas administered by local boards. TAC = 3,200 mt.
1998	Sept. 1: Trip limit raised to 3000 lbs/day, maximum of 30,000 lbs/trip.	Fixed gear vessels 45-65 ft operated on individual quotas. TAC = 3,900 mt.
1999	May 1: Trip limit 2,000 lbs/day, max. 20,000 lbs/trip. Square mesh size increased to 6.5" (diamond is 6"). June 15: Scallop exemption fishery in Closed Area II. Nov. 5: Trip limit 5,000 lbs/day, max. 50,000 lbs/trip.	TAC = 3,900 mt.; mandatory cod separator panel when no observer on board.
2000	October: Daily trip limit suspended to April 2001but retained max. trip limit of 50,000 lbs/trip.	TAC = 5,400 mt.
2001-2002	Day and trip limit adjustments. Daily trip limit suspended July 5, 2002.	TAC = 6,989 and 6,740 mt for 2001 and 2002 respectively.
2002-2003	30,000 – 50,000 lb/trip limit. Trip limit suspended in Oct. 2003.	TAC = 6,933 mt for 2003.
Canada – USA Resource Sharing Agreement on Georges Bank		
2004	May 1, day and trip limits removed. TAC = 5,100 mt. Oct. 1: unit areas 561 and 562 closed to groundfish vessels. Nov. 19: Special Access Program (SAP) for haddock opened. Dec. 31: Haddock SAP closed.	TAC = 9,900 mt.
2005	TAC= 7,590 mt. Jan. 14: separator trawl required.	TAC = 15,410 mt; exploratory winter fishery Jan. to Feb. 18, 2005.
2006	TAC= 7,480 mt; EGB area closed to USA fishery in first half of year when USA cod quota nearly reached.	TAC = 14,520 mt; exploratory winter fishery Jan. to Feb. 6, 2006.
2007	TAC=6,270 mt. June 20: EGB area closed to USA fishery due to USA cod catch nearing quota. August 9: Minimum haddock size reduced to 18 inches October 20: EGB area opened to USA fishery.	TAC = 12,730 mt; exploratory winter fishery Jan. to Feb. 15, 2007

Table 3. Canadian landings (mt) of haddock from eastern Georges Bank during 1969-2007 by gear category and tonnage class for principal gears.

Year	Otter Trawl							Longline				Scallop Fishery	Other	Total
	Side	Stern												
		1[3]	2	3	4	5	Total	1[3]	2	3	Total			
1969	777		0	1	225	2902	3127		2	21	23	15	0	3941
1970	575		2	0	133	1179	1314		6	72	78	2	1	1970
1971	501		0	0	16	939	955		18	129	151	3	0	1610
1972	148		0	0	2	260	263		23	169	195	1	2	609
1973	633		0	0	60	766	826		23	80	105	0	1	1565
1974	27		0	6	8	332	346		29	59	88	1	0	462
1975	222		0	1	60	963	1024		25	81	107	0	0	1353
1976	217		0	2	59	905	967		48	108	156	0	15	1355
1977	370		92	243	18	2025	2378		43	51	94	1	28	2871
1978	2456		237	812	351	5639	7039		121	47	169	17	287	9968
1979	1622		136	858	627	1564	3185		190	80	271	2	0	5080
1980	1444		354	359	950	6254	7917		129	51	587	4	65	10017
1981	478		448	629	737	2344	4159		331	99	1019	1	1	5658
1982	115		189	318	187	3341	4045		497	187	712	0	0	4872
1983	106		615	431	107	1130	2283		593	195	815	1	3	3208
1984	5		180	269	21	149	620		614	192	835	2	1	1463
1985	72		840	1401	155	348	2745		562	33	626	2	39	3484
1986	51		829	1378	95	432	2734		475	98	594	4	32	3415
1987	48		782	1448	49	1241	3521		854	113	1046	38	50	4703
1988[2]	72		1091	1456	186	398	3183		428	200	695	16	80	4046
1989	0		489	573	376	536	1976		713	175	977	12	95	3060
1990	0		928	890	116	471	2411		623	173	853	7	69	3340
1991	0		1610	1647	81	689	4028		900	271	1309	8	111	5456
1992	0		797	1084	56	645	2583		984	245	1384	4	87	4058
1993	0		535	1179	67	699	2489		794	156	1143	2	93	3727
1994	0		495	911	79	112	1597		498	47	714	9	91	2411
1995	0		523	896	14	214	1647		256	75	390	7	21	2065
1996	1		836	1405	166	270	2689		561	107	947	0	26	3663
1997	0		680	1123	91	96	1991		501	116	722	0	36	2749
1998	0		863	1340	98	71	2422		570	252	921	0	28	3371
1999	0		954	1471	174	145	2761		486	241	887	0	32	3680
2000	0		1313	2269	230	246	4146		619	258	1186	0	70	5402
2001	0		1564	2555	0	757	5112		754	302	1633	0	29	6774
2002	0		1217	2720	0	657	4954		794	151	1521	0	12	6488
2003	0		1186	3246	0	0	4985		806	249	1776	0	14	6775
2004	0		2152	4651	0	67	7744		716	223	2000	0	1	9745
2005	0	1467	2929	7393	326	0	12115	1645	646	78	2368	0	1	14484
2006	0	1605	1805	6076	601	0	10088	1321	491	84	1896	0	1	11984
2007	0	1782	1982	6112	159	0	10034	1463	363	28	1854	0	1	11890

[1] Total includes catches for tonnage classes which are not listed, only tonnage classes with substantial catches listed

[2] Catches of 26t, 776t, 1091t and 2t for side otter trawlers and stern otter trawlers tonnage classes 2, 3 and 5 respectively were excluded because of suspected area misreporting.

[3] Tonnage class 1 landings included in 'Total'. Historically, tonnage class 1 accounted for a low proportion of total otter trawl landings but the proportion has increased in recent years.

Table 4. Monthly landings (mt) of haddock by Canada from eastern Georges Bank during 1969-2007.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1969	105	74	6	291	588	691	559	580	551	360	102	34	3941
1970	2	105	0	1	574	345	103	456	242	103	26	12	1970
1971	0	9	1	0	400	132	283	278	97	246	141	21	1610
1972	0	119	2	0	2	111	84	116	98	68	7	2	609
1973	4	10	0	0	0	184	198	572	339	232	22	4	1565
1974	19	0	1	0	0	58	63	53	96	61	92	19	462
1975	4	14	0	0	0	166	256	482	100	166	118	45	1353
1976	0	7	62	68	60	587	152	190	186	26	9	7	1355
1977	102	177	7	0	23	519	1059	835	13	59	56	22	2871
1978	104	932	44	22	21	319	405	85	642	5433	1962	0	9968
1979	123	898	400	175	69	1393	885	396	406	261	53	22	5080
1980	38	134	14	29	223	2956	2300	965	1411	1668	104	176	10017
1981	38	481	568	4	254	1357	1241	726	292	82	378	239	5658
1982	129	309	1	11	46	1060	769	682	585	837	398	44	4872
1983	32	67	29	47	60	1288	387	483	526	195	88	6	3208
1984	3	5	81	88	73	433	219	254	211	71	25	0	1463
1985	1	11	33	99	26	354	392	1103	718	594	61	93	3484
1986	11	28	79	99	40	1339	1059	369	233	139	12	8	3415
1987	24	26	138	70	12	1762	1383	665	405	107	97	14	4703
1988[1]	39	123	67	79	15	1816	1360	315	130	65	13	24	4046
1989	33	94	48	7	20	1398	356	566	141	272	108	18	3060
1990	35	14	50	0	7	1178	668	678	469	199	18	22	3340
1991	144	166	49	26	21	1938	1004	705	566	576	123	137	5456
1992	118	205	97	152	36	1381	619	414	398	401	209	28	4058
1993	468	690	96	78	25	723	505	329	202	198	230	183	3727
1994	3	3	1	2	0	398	693	373	375	220	211	133	2411
1995	5	1	1	1	0	762	327	290	281	109	197	93	2065
1996	0	0	0	0	0	1067	672	706	359	278	191	391	3663
1997	0	0	0	0	0	328	751	772	426	190	116	166	2749
1998	0	0	0	0	0	687	420	580	707	542	164	271	3371
1999	37	0	0	0	0	898	975	562	573	295	269	70	3681
2000	1	0	0	0	0	1368	1175	1026	848	658	175	150	5402
2001	0	0	0	0	0	971	1335	930	1267	1075	647	548	6774
2002	0	0	0	0	0	572	1703	983	1364	820	593	452	6488
2003	0	0	0	0	0	840	1767	1290	930	952	676	320	6775
2004	0	0	0	0	0	1547	2268	2109	1753	1275	556	236	9745
2005	1025	1182	0	0	13	1423	3004	3820	2199	1198	357	266	14484
2006	1176	381	0	0	0	1093	2433	2668	2211	1149	558	316	11984
2007	1100	454	0	0	0	1432	3034	2510	1916	991	231	222	11890

[1] Catches of 3t, 1846t and 46t for Jan., Feb., and Mar., respectively for otter trawlers were excluded because of suspected area misreporting

Table 5. Monthly landings (mt) of haddock by the United States from eastern Georges Bank during 1969-2007. Detail information for landings from 1994 to 2007 were estimated by an allocation algorithm (Wigley et al. 2008).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1969	525	559	976	1826	670	810	204	219	249	226	203	157	6624
1970	169	219	242	375	608	374	324	333	179	219	61	50	3154
1971	155	361	436	483	668	503	338	152	147	165	58	68	3533
1972	150	196	91	90	239	261	97	164	84	63	52	64	1551
1973	90	111	77	85	139	365	217	196	37	3	22	55	1397
1974	135	70	47	70	122	160	165	43	27	6	19	91	955
1975	152	123	32	116	388	489	138	95	57	24	52	39	1705
1976	116	147	84	106	323	162	7	6	5	2	3	13	974
1977	75	211	121	154	374	372	434	191	73	52	146	226	2428
1978	336	437	263	584	752	750	467	221	245	426	194	49	4725
1979	274	329	352	548	766	816	588	659	224	202	282	172	5213
1980	632	1063	742	784	711	461	324	254	221	91	110	222	5615
1981	551	1852	634	628	882	1327	1233	873	321	284	242	255	9081
1982	425	755	502	348	719	1805	757	145	201	216	276	138	6286
1983	492	931	272	181	310	1145	231	178	187	110	227	190	4453
1984	540	961	366	281	627	1047	370	303	250	196	92	89	5121
1985	165	190	254	300	352	206	60	47	1	24	41	43	1683
1986	184	396	334	479	496	221	31	6	12	6	6	29	2201
1987	225	52	43	307	233	342	67	30	24	4	23	68	1418
1988	196	152	207	245	366	316	30	19	6	1	45	110	1694
1989	114	56	47	164	161	145	15	8	1	5	25	46	785
1990	148	21	155	274	214	306	23	3	5	5	16	19	1189
1991	105	28	76	133	89	434	1	20	6	0	19	19	931
1992	253	81	51	150	353	668	20	20	17	3	2	12	1629
1993	15	12	16	55	88	209	6	3	3	7	2	8	424
1994	0	1	1	3	1	1	12	1	0	1	1	2	24
1995	1	1	3	4	2	3	1	0	0	0	1	0	15
1996	2	1	2	3	7	3	3	2	1	1	1	1	26
1997	5	4	3	4	11	6	2	1	9	4	2	6	55
1998	5	19	23	29	31	50	21	17	39	22	1	15	271
1999	35	15	30	52	70	62	23	18	28	0	0	22	356
2000	6	13	89	48	42	22	21	15	24	2	17	42	340
2001	42	9	227	146	81	97	51	12	8	38	21	31	762
2002	92	105	92	150	271	174	66	46	17	42	11	24	1090
2003	94	24	86	506	310	319	57	17	4	51	40	169	1676
2004	97	21	174	718	101	345	256	27	57	5	5	30	1835
2005[1]	2	0	44	34	210	156	103	93	0	0	1	2	645
2006	1	0	0	23	191	86	0	7	0	0	1	3	311
2007	2	0	5	69	45	64	0	0	0	22	40	0	247

[1]Fishery was closed in August when cod by-catch quota reached.

Table 6. United States landings (mt) of haddock from eastern Georges Bank during 1969-2007 by gear category and tonnage class. Detail information for landings from 1994 to 2007 were estimated by an allocation algorithm (Wigley et al. 2008).

Year	Otter Trawl			Other	Total
	3	4	Total		
1969	3013	3610	6624	0	6624
1970	1602	1551	3154	0	3154
1971	1760	1768	3533	0	3533
1972	861	690	1551	0	1551
1973	638	759	1397	0	1397
1974	443	512	955	0	955
1975	1025	679	1705	0	1705
1976	671	303	974	0	974
1977	1724	703	2428	0	2428
1978	3140	1582	4722	3	4725
1979	3285	1927	5212	1	5213
1980	2654	2955	5611	4	5615
1981	3601	5433	9066	15	9081
1982	2589	3660	6249	37	6286
1983	1162	3276	4438	15	4453
1984	1855	3261	5116	5	5121
1985	857	823	1680	4	1683
1986	993	1207	2200	1	2201
1987	766	651	1417	1	1418
1988	920	768	1688	6	1694
1989	359	419	780	6	785
1990	488	697	1185	4	1189
1991	403	523	927	3	931
1992	648	978	1626	3	1629
1993	152	268	420	4	424
1994	12	10	23	1	24
1995	4	11	15	0	15
1996	12	14	26	0	26
1997	35	15	50	5	55
1998	123	147	270	1	271
1999	126	229	355	1	356
2000	107	232	340	1	340
2001	248	513	761	2	762
2002	457	626	1083	7	1090
2003	798	879	1677	0	1676
2004	671	1153	1823	12	1835
2005	239	359	598	48	645
2006	158	110	267	44	311
2007	135	95	230	16	247

Table 7. United States landings and discards of haddock in 2007 by quarter and market category from eastern Georges Bank and National Marine Fisheries Service sampling intensity for lengths and ages. Numbers in ***bold italics*** indicate the number of lengths augmented from adjacent areas. Note that summaries by market category are not possible for discards as the fish are discarded at sea and are not given a market category.

Market Category	Large	Scrod	Unclassified	Total
		Landings (mt)		
Quarter 1	2.92	3.52	0.12	6.57
Quarter 2	38.08	138.89	0.48	177.45
Quarter 3	0.00	0.17	0.00	0.17
Quarter 4	6.37	56.02	0.00	62.39
Total	47.37	198.60	0.60	246.57
		Length per 100 mt (Number measured)		
Quarter 1	0 (***587***)	1560 (55, ***348***)	0	1560 (55, ***935***)
Quarter 2	0 (***906***)	109 (151, ***974***)	0	109 (151, ***1880***)
Quarter 3	N/A (***129***)	0 (***117***)	N/A	0 (***246***)
Quarter 4	1822 (116, ***124***)	418 (234, ***455***)	N/A	2240 (350, ***579***)
Total	1822 (116, ***1746***)	2087 (440, ***1894***)	0	3909 (556, ***3640***)
		Age per 100 mt (Number aged)		
Quarter 1	0	255 (9)	0	255 (9)
Quarter 2	0	52 (72)	0	52 (72)
Quarter 3	N/A	0	N/A	0
Quarter 4	927 (59)	170 (95)	N/A	1096 (154)
Total	927 (59)	477 (176)	0	1404 (235)
		Discards (mt)		
Quarter 1	N/A	N/A	N/A	0.30
Quarter 2	N/A	N/A	N/A	53.81
Quarter 3	N/A	N/A	N/A	0.08
Quarter 4	N/A	N/A	N/A	427.77
Total	N/A	N/A	N/A	481.97
		Lengths per 100 mt (Number measured)		
Quarter 1	N/A	N/A	N/A	127571 (388)
Quarter 2	N/A	N/A	N/A	2083 (1121)
Quarter 3	N/A	N/A	N/A	335116 (283)
Quarter 4	N/A	N/A	N/A	91 (389)
Total	N/A	N/A	N/A	452 (2183)

Table 8. Haddock age and length samples for landings from the Canadian groundfish fishery and for discards from the scallop dredge fishery in 2007 from eastern Georges Bank. (OTB=Otter Trawl Bottom, LL=Long Line, GN=Gill Net, DR=Scallop Dredge)

Qtr.	Gear	Month	Landings (kg)	Length Frequency Samples				Ages[9]
				At Sea		Port		
				Trips	Measured	Samples	Measured	
1	OTB	Jan	1,099,784	47	40,947	9	2,257	Survey = 653
		Feb	453,250	12	12,028	1	240	Port = 69
	DR[1]		10,508	2 (2)[2]	118 (596)[2]			Total = 722[5]
2	OTB	June	1,418,621	78	73,375	5	1,260	Port = 119
	LL	June	13,653	1	102			At Sea = 257
	DR[1]		35,746	4	707			Total = 376[6]
3	OTB	July	2,615,176	115	92,562	4	990	
		Aug	1,917,426	80	68,063	5	1,303	
		Sept	1,316,935	52	39,829	2	610	
	LL	July	418,884			7	1,887	Port = 500
		Aug	591,678	3	2,334	6	1,719	At Sea = 87
		Sept	599,404	3	2,219	2	548	Total = 587[7]
	GN	July[3]	62					
		Aug	1,031			2	213	
		Sept[3]	106					
	DR[1]		14,561	6	1,343			
4	OTB	Oct	784,573	38	33,010	6	1,491	
		Nov	206,252	10	9,728	2	530	Port = 372
		Dec	222,222	12	7,709	2	569	At Sea = 50
	LL	Oct	206,223	3	3,357	4	1,143	Total = 422[8]
		Nov	24,283	1	42	2	526	
	DR[1]		646	2 (2)[4]	58 (199)[4]			
Totals			11,889,563	469	387,531	59	15,286	

[1]Discards from the scallop fishery were estimated by quarter.
[2]Two dredge samples borrowed from April DR.
[3]Combined with August GN
[4]Two dredge samples borrowed from Sept DR.
[5]Ages for 5 length groupings were estimated and are not included in the total.
[6]Ages for 2 length groupings were estimated and are not included in the total.
[7]Ages for 8 length groupings were estimated and are not included in the total.
[8] Ages for 6 length groupings were estimated and are not included in the total.
[9]Otoliths were not available for some lengths. Ages at these lengths with no otoliths sampled were estimated by comparing to other quarters and year class strengths.

Table 9. Components of the 2007 catch at age in numbers of haddock from eastern Georges Bank by quarter.

	Age Group										
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**	**0+**
Canadian Landings											
2007	0	0	149	536	305150	21561	21321	440615	34750	80398	904480
2007.25	0	10	1410	9773	923868	56934	15746	105399	19925	11621	1144685
2007.5	0	0	10212	146312	4762227	53021	106184	673713	59012	72700	5883382
2007.75	0	569	10243	15207	924672	8633	12263	126651	13135	6577	1117952
Year total	0	579	22015	171828	6915918	140149	155515	1346378	126822	171296	9050499
United States Landings[1]											
2007	0	0	0	0	0	0	0	0	0	0	0
2007.25	0	0	0	890	141417	1070	407	42914	3073	2566	192337
2007.5	0	0	0	0	0	0	0	0	0	0	0
2007.75	0	0	0	0	0	0	0	0	0	0	0
Year total	0	0	0	890	141417	1070	407	42914	3073	2566	192337
Canadian Discards											
2007	0	150	142	137	9022	164	37	867	78	176	10774
2007.25	0	114	653	1775	34088	1660	111	713	139	86	39338
2007.5	47	143	997	1293	12616	37	56	328	95	22	15633
2007.75	6	26	139	37	521	1	1	17	1	0	749
Year total	53	432	1930	3242	56248	1863	206	1924	313	285	66494
United States Discards											
2007	0	6	87	11	308	3	3	23	2	11	456
2007.25	0	152	2440	1142	45433	682	1291	7041	849	2192	61223
2007.5	0	1	3	1	78	1	1	1	0	0	87
2007.75	0	5850	40289	6128	372372	5486	3394	6520	1122	2033	445227
Year total	0	6009	42819	7282	418191	6172	4689	13585	1974	4236	506992
Total											
2007	0	156	379	684	314480	21728	21362	441504	34830	80585	915710
2007.25	0	276	4503	13580	1144807	60347	17555	156067	23986	16464	1437583
2007.5	47	143	11212	147606	4774921	53059	106241	674043	59107	72723	5899102
2007.75	6	6445	50671	21372	1297566	14120	15659	133187	14258	8611	1563927
Year total	53	7020	66764	183242	7531774	149253	160816	1404802	132182	178383	9816322

[1]All United States landings were allocated to quarter 2 to calculate numbers at age, however landings occurred in other quarters.

Table 10. Inter- and intra-reader testing for Georges Bank haddock ageing. SS=S. Sutherland (National Marine Fisheries Service, (NMFS)), LVE=L. Van Eeckhaute (Canadian Department of Fisheries and Oceans, DFO), GB=Georges Bank, CV=coefficient of variation.

Sample Source	Test Type	Date Completed	Age Reader	Sample Size	CV (%)	Agreement (%)
2007 DFO Commercial Samples (Q2-4)	Exchange	Spring 2008	SS vs. LVE	56	0.00	100.0
2007 DFO Spring Survey (TEM2007685)	Exchange	Spring 2008	SS vs. LVE	55	0.46	96.4
NMFS Haddock Reference Collection	Accuracy	5/2008	SS	59	1.71	91.5
2008 NMFS Spring Survey (200803)	Precision	5/2008	SS	74	0.52	94.6
2007 United States (USA) Commercial Samples (Q4)	Precision	4/2008	SS	117	0.06	99.1
2007 USA Commercial Samples (Q3)	Precision	3/2008	SS	111	0.31	96.4
2007 USA Commercial Samples (Q2)	Precision	2/2008	SS	110	0.21	97.3
2007 USA Commercial Samples (Q1)	Precision	1/2008	SS	100	0.38	96.0
2007 NMFS Autumn Survey (200709)	Precision	1/2008	SS	77	0.11	98.7
NMFS Haddock Reference Collection	Accuracy	1/2008	SS	55	1.77	89.1

Table 11. Total annual commercial catch at age numbers (000's) of haddock from eastern Georges Bank during 1969-2007. Estimates of discards are included.

Year	Age Group										
	0	1	2	3	4	5	6	7	8	9+	0+
1969	6	0	18	1451	262	334	2909	831	91	283	6184
1970	0	66	84	7	351	151	130	1153	372	193	2508
1971	43	0	1201	251	31	252	159	161	774	412	3284
1972	118	346	1	390	72	21	94	39	16	451	1547
1973	7	1119	1758	6	364	38	10	39	8	169	3517
1974	9	37	2257	276	0	32	3	0	29	63	2706
1975	553	18	279	1504	216	5	36	2	2	31	2645
1976	1	402	157	173	834	135	0	19	0	18	1739
1977	0	1	8028	66	182	307	164	0	15	15	8778
1978	110	6	291	9956	164	173	306	80	10	9	11105
1979	12	212	17	208	4307	364	201	217	43	14	5597
1980	31	32	17701	343	302	2425	193	130	52	12	21220
1981	6	55	693	6773	400	497	1243	119	33	7	9826
1982	1	2	731	1057	2848	205	379	730	62	65	6080
1983	75	11	149	663	554	1653	208	104	409	35	3860
1984	1	72	100	259	350	270	1131	186	166	318	2854
1985	353	9	2146	386	182	199	128	381	53	117	3954
1986	0	89	39	2586	175	143	124	119	174	42	3492
1987	19	0	2081	131	1536	100	58	83	70	111	4190
1988	1	53	53	2199	124	894	111	39	46	100	3619
1989	8	2	1270	85	757	132	326	31	21	45	2677
1990	18	31	8	1334	128	755	69	166	42	42	2593
1991	35	22	466	92	2080	90	393	73	146	61	3458
1992	151	49	249	323	128	1464	89	319	26	91	2891
1993	4	80	283	351	282	87	645	34	155	75	1997
1994	13	34	304	762	153	56	49	129	29	40	1568
1995	4	8	83	546	420	54	26	3	52	17	1213
1996	6	4	34	496	872	424	61	18	3	73	1992
1997	1	30	103	85	549	488	196	13	8	34	1507
1998	19	19	198	295	265	547	453	116	12	35	1960
1999	2	27	44	752	319	248	346	255	99	25	2117
2000	1	6	318	443	1249	250	201	209	182	65	2924
2001	0	23	67	1719	525	831	255	199	226	194	4041
2002	0	1	358	222	1862	370	657	110	106	278	3964
2003	486	5	9	1806	281	1459	419	470	107	227	5269
2004	2	249	18	63	3602	588	1482	513	418	260	7195
2005	0	11	210	29	222	6831	519	804	126	154	8905
2006	1	14	11	2330	43	289	4559	234	555	157	8194
2007	0	7	67	183	7532	149	161	1405	132	178	9816

Table 12. Average weight at age (kg) of haddock from the Canadian commercial groundfish fishery from eastern Georges Bank during 1969-2007. The 1989 to 1991 year-classes (shaded) grew faster than adjacent year-classes.

Year	Age Group							
	1	2	3	4	5	6	7	8
1969	0.600	0.763	1.282	1.531	1.649	1.836	2.298	2.879
1970	0.721	1.067	0.812	1.653	1.886	2.124	2.199	2.841
1971	0.600	0.928	1.059	1.272	2.011	2.255	2.262	2.613
1972	0.759	1.000	1.562	1.750	2.147	2.505	2.411	2.514
1973	0.683	1.002	1.367	1.804	2.202	1.631	2.885	3.295
1974	0.600	0.970	1.418	1.800	1.984	3.760	2.700	3.128
1975	0.600	0.872	1.524	2.062	1.997	2.422	4.114	3.557
1976	0.596	0.956	1.293	1.857	2.417	2.700	2.702	3.000
1977	0.600	0.970	1.442	1.809	2.337	2.809	2.700	3.095
1978	0.619	1.151	1.433	2.055	2.623	2.919	2.972	2.829
1979	0.600	0.987	1.298	1.805	2.206	2.806	3.219	3.277
1980	0.405	0.892	1.034	1.705	2.115	2.593	3.535	3.608
1981	0.600	0.890	1.262	1.592	2.270	2.611	3.505	4.009
1982	0.600	0.965	1.363	1.786	2.327	2.557	2.958	3.531
1983	0.600	1.024	1.341	1.750	2.118	2.509	2.879	3.104
1984	0.600	0.876	1.354	1.838	2.159	2.605	2.856	3.134
1985	0.600	0.950	1.230	1.915	2.227	2.702	2.872	3.180
1986	0.452	0.981	1.352	1.866	2.367	2.712	2.969	3.570
1987	0.600	0.833	1.431	1.984	2.148	2.594	2.953	3.646
1988	0.421	0.974	1.305	1.708	2.042	2.350	3.011	3.305
1989	0.600	0.868	1.450	1.777	2.183	2.522	3.012	3.411
1990	0.639	0.999	1.419	1.787	2.141	2.509	2.807	3.002
1991	0.581	1.197	1.241	1.802	2.087	2.596	2.918	3.012
1992	0.538	1.163	1.622	1.654	2.171	2.491	2.988	3.388
1993	0.659	1.160	1.724	2.181	2.047	2.623	2.386	3.112
1994	0.405	1.135	1.661	2.235	2.639	2.422	2.831	3.223
1995	0.797	1.055	1.511	2.033	2.550	2.755	2.908	3.010
1996	0.576	1.022	1.439	1.795	2.294	2.485	3.322	2.032
1997	0.685	1.215	1.336	1.747	2.120	2.476	3.034	3.365
1998	0.568	1.131	1.573	1.697	1.983	2.312	2.864	3.395
1999	0.678	1.095	1.570	1.910	1.865	2.182	2.535	2.773
2000	0.664	1.103	1.470	1.920	2.242	2.098	2.497	2.816
2001	0.394	1.102	1.471	1.755	2.107	2.367	2.186	2.522
2002	0.405	1.009	1.417	1.762	1.940	2.339	2.657	2.377
2003	0.475	0.758	1.381	1.589	1.851	1.894	2.343	2.839
2004	0.482	0.589	1.102	1.514	1.643	1.880	2.002	2.282
2005	0.056[1]	0.697	0.989	1.433	1.685	1.857	2.041	2.059
2006	0.335	0.514	0.977	0.978	1.603	1.783	1.872	2.019
2007	0.464	0.584	0.990	1.189	1.384	1.655	1.829	1.658
Low	0.335[2]	0.514	0.812	0.978	1.384	1.631	1.829	1.658
High	0.797[2]	1.215	1.724	2.235	2.639	3.760	4.114	4.009
Median	0.600[2]	0.981	1.367	1.786	2.120	2.491	2.856	3.095
Average	0.577[2]	0.960	1.346	1.751	2.097	2.417	2.744	2.985
Avg. 2005-07	0.400[2]	0.598	0.986	1.200	1.557	1.765	1.914	1.912

[1]One haddock measured.
[2]Excludes 2005 value.

Table 13. Average lengths at age (cm) of haddock from the eastern Georges Bank Canadian commercial fishery during 1969-2007. The 1989 to 1991 year-classes (shaded) grew faster than adjacent year-classes.

Year	Age Group							
	1	2	3	4	5	6	7	8
1985		43.2	47.6	56.1	56.8	63.6	66.3	65.8
1986	33.7	43.8	50.1	56.2	63.4	62.8	68.7	72.3
1987		41.4	49.2	56.6	57.5	60.2	62.9	68.2
1988	32.8	43.7	48.4	53.7	58.1	58.1	64.1	64.1
1989		41.8	49.7	53.8	57.8	61.2	62.3	64.1
1990	37.9	43.5	50.2	52.9	58.0	57.8	62.0	59.3
1991	36.2	47.0	47.0	54.2	56.0	61.5	58.9	63.2
1992	35.7	46.4	52.6	52.6	58.1	56.3	64.0	61.2
1993	38.3	46.4	53.4	58.1	56.9	61.6	64.0	65.1
1994	32.5	46.1	52.6	58.1	61.6	59.5	62.8	65.4
1995	40.2	45.0	50.8	56.2	60.8	62.4	63.5	64.2
1996	36.4	44.5	50.0	53.8	58.6	60.0	66.6	56.5
1997	38.6	47.2	48.8	53.4	57.0	60.2	64.4	66.9
1998	36.5	46.1	51.6	52.8	55.7	58.7	63.3	67.2
1999	38.7	45.6	51.5	55.1	54.5	57.4	60.5	62.4
2000	38.5	45.6	50.4	55.2	58.2	56.3	59.9	62.6
2001	32.1	45.5	50.4	53.5	56.9	59.2	57.6	60.3
2002	32.5	44.3	49.7	53.5	55.2	58.9	61.5	59.0
2003	34.2	40.2	49.3	51.6	54.4	54.8	58.9	63.1
2004	34.5	36.9	45.6	50.8	52.3	54.7	55.9	58.3
2005	16.5[1]	38.8	44.0	49.8	52.8	54.5	56.1	56.3
2006	30.4	35.2	43.7	43.9	51.9	53.8	54.7	56.0
2007	34.0	36.7	43.9	46.8	49.2	52.4	54.2	52.1
Low	30.4[2]	35.2	43.7	43.9	49.2	52.4	54.2	52.1
High	40.2[2]	47.2	53.4	58.1	63.4	63.6	68.7	72.3
Median	35.7[2]	44.3	49.7	53.7	56.9	58.9	62.3	63.1
Average	35.5[2]	43.3	49.2	53.4	56.6	58.5	61.4	62.3
Avg. 2005-07	32.2[2]	36.9	43.9	46.8	51.3	53.5	55.0	54.8

[1]One haddock measured.
[2]Excludes 16.5 cm value in 2005.

Table 14. Conversion factors used to adjust for changes in door type and survey vessel in the National Marine Fisheries Service surveys during 1968-2008.

Year	Door	Spring		Fall	
		Vessel	Conversion	Vessel	Conversion
1968	BMV	Albatross IV	1.49	Albatross IV	1.49
1969	BMV	Albatross IV	1.49	Albatross IV	1.49
1970	BMV	Albatross IV	1.49	Albatross IV	1.49
1971	BMV	Albatross IV	1.49	Albatross IV	1.49
1972	BMV	Albatross IV	1.49	Albatross IV	1.49
1973	BMV	Albatross IV	1.49	Albatross IV	1.49
1974	BMV	Albatross IV	1.49	Albatross IV	1.49
1975	BMV	Albatross IV	1.49	Albatross IV	1.49
1976	BMV	Albatross IV	1.49	Albatross IV	1.49
1977	BMV	Albatross IV	1.49	Delaware II	1.2218
1978	BMV	Albatross IV	1.49	Delaware II	1.2218
1979	BMV	Albatross IV	1.49	Delaware II	1.2218
1980	BMV	Albatross IV	1.49	Delaware II	1.2218
1981	BMV	Delaware II	1.2218	Delaware II	1.2218
1982	BMV	Delaware II	1.2218	Albatross IV	1.49
1983	BMV	Albatross IV	1.49	Albatross IV	1.49
1984	BMV	Albatross IV	1.49	Albatross IV	1.49
1985	Polyvalent	Albatross IV	1	Albatross IV	1
1986	Polyvalent	Albatross IV	1	Albatross IV	1
1987	Polyvalent	Albatross IV	1	Albatross IV	1
1988	Polyvalent	Albatross IV	1	Albatross IV	1
1989	Polyvalent	Delaware II	0.82	Delaware II	0.82
1990	Polyvalent	Delaware II	0.82	Delaware II	0.82
1991	Polyvalent	Delaware II	0.82	Delaware II	0.82
1992	Polyvalent	Albatross IV	1	Albatross IV	1
1993	Polyvalent	Albatross IV	1	Delaware II	0.82
1994	Polyvalent	Delaware II	0.82	Albatross IV	1
1995	Polyvalent	Albatross IV	1	Albatross IV	1
1996	Polyvalent	Albatross IV	1	Albatross IV	1
1997	Polyvalent	Albatross IV	1	Albatross IV	1
1998	Polyvalent	Albatross IV	1	Albatross IV	1
1999	Polyvalent	Albatross IV	1	Albatross IV	1
2000	Polyvalent	Albatross IV	1	Albatross IV	1
2001	Polyvalent	Albatross IV	1	Albatross IV	1
2002	Polyvalent	Albatross IV	1	Albatross IV	1
2003	Polyvalent	Delaware II	0.82	Delaware II	0.82
2004	Polyvalent	Albatross IV	1	Albatross IV	1
2005	Polyvalent	Albatross IV	1	Albatross IV	1
2006	Polyvalent	Albatross IV	1	Albatross IV	1
2007	Polyvalent	Albatross IV	1	Albatross IV	1
2008	Polyvalent	Albatross IV	1		

Table 15. Total swept area estimates of abundance at age (numbers in 000's) of eastern Georges Bank haddock from the Canadian Department Fisheries Oceans (DFO) surveys during 1986-2008.

Year	Age Group									
	1	2	3	4	5	6	7	8	9+	Total
1986	5057	306	8176	997	189	348	305	425	401	16205
1987	46	4286	929	3450	653	81	387	135	1132	11099
1988	971	49	12714	257	4345	274	244	130	686	19670
1989	48	6664	991	2910	245	526	40	34	265	11724
1990	726	108	12300	168	4466	299	1370	144	389	19968
1991	383	2163	134	10819	114	1909	117	505	225	16368
1992	1914	3879	1423	221	4810	18	1277	52	656	14249
1993	3448	1759	545	431	34	1186	19	281	147	7849
1994	4197	15163	5332	549	314	20	915	18	356	26864
1995	1231	3224	6236	3034	720	398	0	729	849	16422
1996	1455	2290	4784	5305	3113	303	274	38	684	18247
1997	1033	1550	1222	2742	2559	1397	150	65	372	11090
1998	2379	10626	5348	3190	5312	5028	2248	348	601	35080
1999	24593	4787	10067	3104	1963	1880	1764	448	174	48780
2000	3177	15865	7679	12108	2900	2074	2726	1591	813	48932
2001	23026	3519	14633	4255	5608	1808	1426	1963	2299	58536
2002	732	28174	5977	12660	2981	2646	648	529	2423	56769
2003	1682	1503	82161	5533	15105	3675	2355	1106	1986	115107
2004	91843	539	2682	54882	5001	9695	1654	954	634	167883
2005	1669	20958	531	1557	25559	3403	4815	1087	548	60125
2006	9130	5817	178604	2521	2251	15695	764	1633	261	216675
2007	3051	9541	3289	67311	984	154	3584	251	652	88816
2008	3832	1219	4647	5025	103874	1006	191	8553	724	129071

Table 16. Total swept area estimated abundance at age (numbers in 000's) of eastern Georges Bank haddock from National Marine Fisheries Service spring surveys during 1968-2008. From 1973-81, a 41 Yankee trawl was used while a 36 Yankee trawl was used in other years. Conversion factors to adjust for changes in door type and survey vessel were applied.

Year	Age Group									
	1	2	3	4	5	6	7	8	9+	Total
1968	0	3254	68	679	4853	2045	240	123	234	11496
1969	17	35	614	235	523	3232	1220	358	489	6724
1970	478	190	0	560	998	441	3165	2491	769	9092
1971	0	655	261	0	144	102	58	1159	271	2650
1972	2594	0	771	132	25	47	211	27	1214	5020
1973	2455	5639	0	1032	154	0	276	0	1208	10763
1974	1323	20596	4084	0	354	0	43	72	322	26795
1975	528	567	6016	1063	0	218	127	45	208	8773
1976	8228	402	424	1127	532	0	0	0	22	10735
1977	126	26003	262	912	732	568	0	22	102	28727
1978	0	743	20859	641	880	1163	89	23	116	24516
1979	10496	441	1313	9764	475	72	445	42	9	23056
1980	4355	66450	1108	1086	5761	613	371	693	360	80797
1981	3281	2823	27085	2906	751	2455	347	56	21	39725
1982	584	3703	1658	7802	767	455	697	0	0	15666
1983	238	770	686	359	2591	30	0	798	58	5529
1984	1366	1414	1046	910	847	1189	133	73	490	7469
1985	40	8911	1396	674	1496	588	1995	127	483	15709
1986	3334	280	3597	246	210	333	235	560	159	8953
1987	122	5480	144	1394	157	231	116	370	0	8013
1988	305	61	1868	235	611	203	218	178	0	3678
1989	84	6665	619	1343	267	791	58	92	47	9966
1990	1654	70	10338	598	1042	110	182	0	0	13995
1991	740	2071	432	3381	192	203	66	87	25	7198
1992	529	287	205	158	602	32	46	46	0	1905
1993	1870	1116	197	232	195	717	77	35	43	4480
1994	1025	4272	1487	269	184	118	278	28	84	7745
1995	921	2312	4184	1727	265	152	51	272	214	10099
1996	912	1365	3789	3190	1905	237	36	0	496	11931
1997	1635	1226	380	595	470	343	24	44	20	4736
1998	549	6046	2005	1281	1184	303	58	15	122	11562
1999	6286	1914	3655	661	1128	1062	468	476	46	15696
2000	2675	2131	3399	1624	636	564	438	305	165	11938
2001	10503	1186	3304	1232	374	294	113	20	20	17047
2002	231	40432	10938	4044	1492	473	287	229	236	58362
2003	125	1105	16915	2245	3773	476	200	82	286	25206
2004	195013	4724	2644	45872	3544	5261	960	1245	842	260104
2005	540	32911	257	614	5818	671	1196	240	67	42313
2006	2961	1247	48882	213	949	6650	325	574	187	61988
2007	1468	11383	2055	95882	180	441	2168	222	312	114110
2008	3402	1671	4332	240	38569	836	371	1739	480	51639

Table 17. Total swept area estimated abundance at age (numbers in 000's) of eastern Georges Bank haddock from National Marine Fisheries Service fall surveys during 1963-2007. Conversion factors to adjust for changes in door type and survey vessel were applied.

Year	Age Group									
	0	1	2	3	4	5	6	7	8+	Total
1963	105993	40995	10314	3378	5040	4136	1477	451	276	172061
1964	1178	123976	46705	4358	807	1865	477	211	167	179742
1965	259	1503	51338	8538	479	302	142	148	208	62918
1966	9325	751	1742	20323	3631	671	138	133	84	36798
1967	0	3998	73	327	1844	675	141	88	88	7233
1968	55	113	800	28	37	2223	547	177	313	4293
1969	356	0	0	509	62	30	739	453	108	2257
1970	0	6400	336	16	415	337	500	902	578	9483
1971	2626	0	788	97	0	265	27	73	594	4471
1972	4747	2396	0	232	0	0	53	0	275	7702
1973	1223	16797	1598	0	168	0	0	8	16	19809
1974	151	234	961	169	0	6	0	0	70	1589
1975	30365	664	192	1042	239	0	0	0	28	32530
1976	738	121717	431	25	484	71	0	17	37	123521
1977	47	238	26323	445	125	211	84	4	4	27480
1978	14642	547	530	7706	56	42	94	0	0	23617
1979	1598	21605	14	335	1489	45	12	0	0	25098
1980	3556	2788	5829	0	101	1081	108	25	4	13492
1981	596	4617	2585	2748	89	136	318	0	15	11103
1982	62	0	673	465	2508	153	97	528	42	4527
1983	3609	444	236	501	289	402	17	12	86	5598
1984	45	3775	856	233	194	45	262	0	41	5451
1985	12148	381	1646	199	70	68	46	30	21	14611
1986	30	7471	109	961	52	50	72	24	23	8793
1987	508	0	843	28	152	38	22	0	0	1592
1988	122	3983	184	2348	155	400	142	140	38	7513
1989	167	83	2645	112	509	68	73	0	0	3656
1990	1217	1041	36	1456	65	196	24	5	0	4040
1991	705	331	267	52	289	25	10	0	0	1679
1992	3484	1052	172	110	0	95	0	18	18	4948
1993	687	6656	3601	585	0	87	96	30	0	11742
1994	625	782	927	419	96	32	0	24	0	2905
1995	892	1436	5993	3683	550	30	0	0	53	12637
1996	1742	453	570	2302	963	167	0	0	0	6196
1997	217	5738	3368	592	690	385	0	0	13	11004
1998	2566	2966	4214	1085	705	526	722	0	0	12784
1999	3268	1236	5364	5060	837	2825	148	1150	991	20879
2000	1368	5284	6226	3712	622	229	0	146	97	17684
2001	659	16626	1382	6939	3000	1586	306	127	58	30684
2002	172	1864	44602	6040	5120	1660	863	457	354	61131
2003	196182	60	285	3415	655	739	20	99	158	201613
2004	2864	116289	322	775	17200	1034	2410	416	528	141837
2005	4981	3114	95159	340	532	3631	347	242	155	108502
2006	930	8752	1040	65817	1083	82	796	0	16	78517
2007	1264	1922	11764	965	52456	955	562	244	0	70132

Table 18. Average weight at age (kg) of eastern Georges Bank haddock from Canadian Department of Fisheries and Oceans surveys during 1986-2008, which are used to represent beginning of year weights.

Year	Age Group								
	1	2	3	4	5	6	7	8	9+
1986	0.135	0.451	0.974	1.445	3.044	2.848	3.598	3.376	3.918
1987	0.150	0.500	0.716	1.672	2.012	2.550	3.148	3.151	3.629
1988	0.097	0.465	0.931	1.795	1.816	1.918	2.724	3.264	3.871
1989	0.062	0.474	0.650	1.392	1.995	2.527	2.158	2.859	3.141
1990	0.149	0.525	0.924	1.181	1.862	2.073	2.507	2.815	3.472
1991	0.120	0.685	0.800	1.512	1.695	2.434	2.105	3.122	3.432
1992	0.122	0.602	1.118	1.061	2.078	2.165	2.709	2.284	3.440
1993	0.122	0.481	1.227	1.803	1.274	2.332	2.343	2.739	3.280
1994	0.107	0.469	1.047	1.621	1.927	2.154	3.154	2.688	3.084
1995	0.086	0.493	0.963	1.556	2.222	2.445		2.991	3.184
1996	0.139	0.495	0.919	1.320	1.932	2.555	2.902	2.611	3.588
1997	0.132	0.506	0.782	1.205	1.664	2.176	2.454	2.577	3.158
1998	0.107	0.535	1.035	1.161	1.570	1.954	2.609	3.559	3.462
1999	0.130	0.474	0.911	1.290	1.259	1.869	2.131	2.722	2.992
2000	0.116	0.543	0.949	1.478	1.871	1.789	2.298	2.508	2.901
2001	0.093	0.524	1.005	1.371	1.798	2.165	2.250	2.593	2.928
2002	0.096	0.332	0.778	1.138	1.494	1.965	2.177	2.206	2.708
2003	0.080	0.369	0.846	1.063	1.477	1.645	2.208	2.229	2.487
2004	0.064	0.310	0.781	1.151	1.306	1.558	1.622	1.956	2.216
2005	0.028	0.218	0.493	0.696	1.226	1.321	1.531	1.600	2.444
2006	0.059	0.171	0.389	0.657	0.870	1.366	1.591	1.742	2.355
2007	0.077	0.246	0.405	0.709	0.992	1.745	1.559	1.671	1.862
2008	0.107	0.329	0.573	0.795	0.927	1.254	1.729	1.476	1.897
Low	0.028	0.171	0.389	0.657	0.870	1.254	1.531	1.476	1.862
High	0.150	0.685	1.227	1.803	3.044	2.848	3.598	3.559	3.918
Median	0.107	0.474	0.911	1.290	1.695	2.073	2.274	2.611	3.141
Average	0.103	0.443	0.835	1.264	1.666	2.035	2.341	2.554	3.019
Avg. 2006-08	0.081	0.249	0.456	0.720	0.930	1.455	1.626	1.629	2.038
Avg. 1991-2000	0.118	0.528	0.975	1.401	1.749	2.187	2.523	2.780	3.252

Table 19. Average lengths at age (cm) of eastern Georges Bank haddock from the Canadian Department of Fisheries and Oceans surveys during 1986-2008.

Year	Age Group								
	1	2	3	4	5	6	7	8	9+
1986	22.9	36.2	45.4	51.0	63.7	61.9	67.8	66.0	70.7
1987	24.2	36.3	39.7	53.4	57.1	61.1	65.1	65.8	69.6
1988	22.3	36.4	45.1	55.7	55.9	58.0	62.4	65.8	71.5
1989	19.5	35.9	39.1	50.4	56.8	61.3	58.0	64.6	66.3
1990	24.7	35.8	44.4	48.0	55.9	58.7	61.6	63.1	67.5
1991	23.1	40.7	42.7	51.7	52.9	60.2	58.3	65.1	67.8
1992	23.2	39.2	47.7	46.8	57.7	62.5	63.9	60.3	68.1
1993	23.6	36.6	49.7	55.5	50.0	60.4	59.3	63.7	67.3
1994	22.3	35.8	45.8	53.8	57.6	58.5	65.9	66.5	65.4
1995	20.2	36.3	45.1	52.7	59.0	62.5		65.0	66.0
1996	24.2	36.2	44.4	50.1	56.9	62.7	66.2	61.8	68.4
1997	23.6	37.1	42.1	48.9	54.2	59.5	62.4	63.5	66.8
1998	21.8	37.6	46.4	47.3	52.9	57.2	62.5	69.3	68.7
1999	23.7	35.9	44.8	49.8	48.9	56.1	58.9	63.6	66.6
2000	22.7	37.6	44.3	52.1	56.4	54.7	59.6	61.7	64.7
2001	21.7	37.5	46.1	51.1	56.2	60.0	59.0	62.5	65.5
2002	21.5	31.8	42.1	47.5	52.0	58.1	60.3	59.2	64.4
2003	20.2	34.0	43.3	46.8	52.0	53.8	61.2	61.3	63.3
2004	19.1	31.8	42.0	47.9	50.6	53.3	55.3	59.1	60.2
2005	15.1	29.1	37.2	41.1	49.7	51.6	53.8	54.3	62.7
2006	18.7	27.0	34.0	40.2	42.6	51.8	52.8	55.7	62.2
2007	20.6	29.6	34.2	41.0	46.7	55.0	53.5	54.1	55.4
2008	23.1	33.1	39.4	43.0	45.7	50.5	56.3	52.9	57.9
Low	15.1	27.0	34.0	40.2	42.6	51.6	52.8	54.1	55.4
High	24.7	40.7	49.7	55.7	63.7	62.7	67.8	69.3	71.5
Median	22.3	36.2	44.3	50.0	55.0	58.6	60.3	63.3	66.3
Average	21.8	35.2	43.0	49.2	53.9	58.1	60.4	62.4	65.5

Table 20. Statistical properties of estimates of population abundance (numbers in 000's) at time 2008 and survey calibration constants (unitless, survey:population) for eastern Georges Bank haddock obtained from a bootstrap with 1000 replications.

Age	Estimate	Standard Error	Relative Error	Bias	Relative Bias
		Population Abundance (000's)			
1	15851	9375	0.591	2028	0.128
2	6073	2478	0.408	374	0.062
3	18916	5987	0.316	922	0.049
4	3659	982	0.268	154	0.042
5	141802	34106	0.241	5566	0.039
6	779	185	0.237	13	0.017
7	538	168	0.313	13	0.025
8	7700	1888	0.245	87	0.011
		Survey Calibration Constants			
Canadian Department of Fisheries and Oceans Survey					
1	0.235	0.044	0.186	0.005	0.020
2	0.429	0.081	0.188	0.008	0.020
3	0.848	0.158	0.186	0.018	0.022
4	0.912	0.164	0.180	0.022	0.024
5	1.025	0.195	0.190	0.011	0.011
6	0.848	0.153	0.181	0.017	0.020
7	0.945	0.183	0.194	0.016	0.017
8	0.921	0.177	0.193	0.021	0.023
National Marine Fisheries Service (NMFS) Spring Survey – Yankee 36 – 1969-72/1982-2006					
1	0.132	0.022	0.167	0.001	0.006
2	0.339	0.058	0.170	0.004	0.013
3	0.438	0.072	0.163	0.007	0.016
4	0.416	0.067	0.160	0.005	0.012
5	0.486	0.077	0.159	0.003	0.006
6	0.431	0.069	0.160	0.006	0.013
7	0.405	0.065	0.162	0.004	0.011
8	0.444	0.076	0.172	0.008	0.019
NMFS Spring Survey – Yankee 41 – 1973-81					
1	0.228	0.075	0.327	0.010	0.042
2	0.535	0.161	0.300	0.020	0.037
3	0.653	0.204	0.313	0.028	0.043
4	0.807	0.262	0.325	0.028	0.034
5	0.897	0.293	0.326	0.032	0.036
6	0.813	0.304	0.374	0.047	0.058
7	1.491	0.483	0.324	0.054	0.036
8	0.725	0.255	0.352	0.062	0.086
NMFS Fall Survey					
0	0.128	0.018	0.142	0.001	0.011
1	0.309	0.046	0.148	0.003	0.011
2	0.251	0.038	0.151	0.004	0.015
3	0.246	0.036	0.145	0.003	0.010
4	0.205	0.031	0.153	0.004	0.022
5	0.172	0.025	0.149	0.002	0.014

Table 21. Beginning of year population abundance (numbers in 000's) for eastern Georges Bank haddock during 1969-2008 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2008.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
1969	804	193	3639	872	911	7650	2496	250	776	17590	16787	16594
1970	3592	658	141	1681	479	447	3659	1299	506	12461	8868	8211
1971	234	2881	463	109	1060	256	249	1961	971	8185	7950	5069
1972	5301	192	1284	155	62	642	69	61	1339	9106	3805	3613
1973	11635	4029	156	702	63	32	441	21	728	17806	6172	2143
1974	3079	8517	1727	122	250	18	17	326	454	14511	11432	2915
1975	3443	2488	4946	1165	100	176	12	14	556	12900	9457	6970
1976	54026	2803	1785	2700	760	78	111	8	437	62709	8682	5879
1977	6015	43870	2153	1305	1462	501	64	74	348	55792	49778	5907
1978	4039	4923	28693	1703	905	921	263	52	319	41818	37779	32856
1979	52243	3302	3768	14569	1247	586	480	143	286	76623	24380	21078
1980	6213	42581	2688	2897	8062	694	299	199	300	63934	57720	15139
1981	4591	5058	19032	1891	2100	4425	394	129	351	37971	33380	28323
1982	2054	3709	3517	9514	1189	1273	2507	216	356	24334	22281	18571
1983	2473	1680	2380	1930	5234	789	701	1397	354	16938	14465	12785
1984	15918	2015	1241	1353	1083	2802	459	481	1035	26387	10469	8454
1985	1579	12967	1560	783	793	644	1282	209	808	20624	19045	6078
1986	13654	1285	8684	931	477	471	412	707	679	27300	13646	12362
1987	1546	11098	1016	4789	604	263	274	231	941	20762	19216	8118
1988	15711	1265	7214	714	2544	405	163	150	797	28962	13251	11985
1989	864	12816	989	3933	473	1281	231	99	643	21329	20465	7649
1990	2330	706	9348	733	2539	269	756	162	548	17389	15059	14354
1991	1989	1879	571	6452	485	1401	158	470	505	13910	11920	10041
1992	7907	1609	1120	385	3417	316	795	64	612	16224	8317	6708
1993	12016	6429	1093	627	200	1489	178	365	448	22845	10829	4399
1994	11368	9766	5008	580	261	86	642	115	459	28286	16918	7153
1995	5641	9277	7721	3414	338	163	27	410	408	27400	21759	12482
1996	5560	4611	7520	5829	2417	228	110	20	608	26903	21343	16732
1997	16775	4548	3745	5709	3988	1597	132	74	445	37012	20237	15689
1998	8120	13707	3631	2989	4179	2825	1131	96	386	37065	28945	15238
1999	27246	6631	11043	2707	2209	2929	1905	821	352	55842	28596	21966
2000	8859	22282	5389	8363	1929	1584	2086	1329	849	52671	43812	21530
2001	77011	7248	17956	4013	5723	1354	1116	1519	1561	117500	40489	33242
2002	3490	63030	5874	13151	2813	3937	879	734	2143	96050	92560	29530
2003	2610	2856	51282	4608	9089	1969	2632	621	2010	77677	75067	72211
2004	322723	2132	2331	40356	3520	6127	1235	1731	1853	382008	59286	57153
2005	6715	263998	1729	1851	29792	2352	3685	553	2325	313001	306286	42288
2006	26949	5488	215953	1390	1316	18250	1459	2294	2104	275205	248255	242767
2007	6970	22052	4484	174703	1099	817	10845	984	2960	224914	217944	195892
2008	13823	5700	17994	3506	136236	766	524	7613	2949	189111	175288	169588

Table 22. Fishing mortality rate for eastern Georges Bank haddock during 1969-2007 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2008. The aggregated rates are weighted by population numbers. The rates for ages 4+ and 5+ are also shown as exploitation rate (%).

Year	Age Group												
	1	2	3	4	5	6	7	8	9+	4+	4+(%)	5+	5+(%)
1969	0.000	0.111	0.573	0.399	0.512	0.538	0.453	0.508	0.508	0.508	36.4	0.516	36.8
1970	0.021	0.152	0.057	0.261	0.425	0.383	0.424	0.377	0.538	0.387	29.3	0.421	31.3
1971	0.000	0.608	0.892	0.369	0.302	1.114	1.203	0.565	0.623	0.577	40.1	0.582	40.4
1972	0.075	0.005	0.404	0.705	0.468	0.175	0.973	0.342	0.460	0.410	30.7	0.389	29.4
1973	0.112	0.647	0.045	0.831	1.057	0.410	0.101	0.571	0.294	0.470	34.2	0.273	21.7
1974	0.013	0.344	0.193	0.000	0.154	0.181	0.015	0.103	0.164	0.127	10.8	0.141	12.0
1975	0.006	0.132	0.405	0.227	0.052	0.255	0.219	0.219	0.063	0.176	14.6	0.106	9.1
1976	0.008	0.064	0.113	0.414	0.217	0.000	0.208	0.000	0.046	0.324	25.2	0.150	12.6
1977	0.000	0.225	0.035	0.166	0.262	0.445	0.000	0.247	0.048	0.228	18.6	0.262	21.0
1978	0.002	0.067	0.478	0.112	0.235	0.453	0.406	0.244	0.033	0.228	18.6	0.309	24.2
1979	0.004	0.006	0.063	0.392	0.386	0.471	0.680	0.402	0.056	0.397	29.9	0.422	31.4
1980	0.006	0.605	0.151	0.122	0.400	0.364	0.641	0.336	0.046	0.329	25.6	0.392	29.6
1981	0.013	0.163	0.493	0.264	0.301	0.368	0.403	0.331	0.024	0.320	24.9	0.334	25.9
1982	0.001	0.244	0.400	0.398	0.210	0.396	0.385	0.380	0.225	0.376	28.6	0.339	26.2
1983	0.005	0.103	0.364	0.378	0.425	0.341	0.178	0.387	0.114	0.378	28.7	0.377	28.7
1984	0.005	0.056	0.261	0.334	0.320	0.582	0.586	0.474	0.410	0.465	33.9	0.495	35.7
1985	0.006	0.201	0.317	0.294	0.321	0.246	0.395	0.328	0.173	0.301	23.6	0.302	23.7
1986	0.007	0.034	0.395	0.232	0.397	0.341	0.380	0.315	0.070	0.270	21.6	0.283	22.4
1987	0.000	0.231	0.153	0.433	0.201	0.276	0.404	0.401	0.139	0.366	28.0	0.229	18.6
1988	0.004	0.047	0.407	0.211	0.486	0.359	0.302	0.413	0.149	0.369	28.2	0.397	29.9
1989	0.003	0.116	0.099	0.238	0.366	0.328	0.159	0.264	0.081	0.247	19.9	0.260	20.8
1990	0.015	0.012	0.171	0.214	0.394	0.333	0.275	0.339	0.089	0.311	24.4	0.328	25.5
1991	0.012	0.318	0.195	0.436	0.228	0.367	0.697	0.417	0.143	0.403	30.2	0.332	25.8
1992	0.007	0.187	0.380	0.454	0.631	0.371	0.578	0.592	0.180	0.547	38.5	0.553	38.9
1993	0.007	0.050	0.433	0.676	0.644	0.640	0.238	0.621	0.203	0.564	39.5	0.538	38.1
1994	0.003	0.035	0.183	0.340	0.270	0.950	0.248	0.324	0.101	0.277	22.0	0.253	20.3
1995	0.002	0.010	0.081	0.145	0.193	0.191	0.122	0.151	0.046	0.142	12.0	0.134	11.4
1996	0.001	0.008	0.075	0.180	0.214	0.349	0.201	0.194	0.142	0.191	15.8	0.210	17.2
1997	0.002	0.025	0.025	0.112	0.145	0.145	0.116	0.128	0.089	0.127	10.8	0.140	11.9
1998	0.003	0.016	0.094	0.103	0.155	0.194	0.120	0.147	0.106	0.146	12.3	0.161	13.5
1999	0.001	0.007	0.078	0.139	0.132	0.139	0.159	0.141	0.082	0.140	11.8	0.140	11.9
2000	0.001	0.016	0.095	0.179	0.153	0.150	0.117	0.163	0.089	0.159	13.4	0.137	11.7
2001	0.000	0.010	0.111	0.155	0.174	0.232	0.218	0.178	0.147	0.175	14.6	0.182	15.1
2002	0.000	0.006	0.042	0.169	0.156	0.202	0.147	0.172	0.153	0.171	14.3	0.173	14.4
2003	0.002	0.003	0.039	0.069	0.193	0.266	0.217	0.208	0.132	0.170	14.2	0.199	16.4
2004	0.001	0.009	0.029	0.102	0.201	0.306	0.599	0.305	0.167	0.151	12.7	0.287	22.8
2005	0.002	0.001	0.018	0.137	0.285	0.273	0.270	0.283	0.075	0.264	21.1	0.270	21.6
2006	0.001	0.002	0.011	0.033	0.264	0.310	0.189	0.300	0.085	0.268	21.4	0.281	22.3
2007	0.001	0.003	0.043	0.046	0.154	0.225	0.146	0.154	0.067	0.054	4.8	0.137	11.6

Table 23. Beginning of year biomass for eastern Georges Bank haddock during 1969-2008 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2008.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
1969	92	99	3402	1311	1815	17936	6780	733	2674	34843	34751	34652
1970	413	339	132	2527	954	1048	9937	3804	1742	20896	20483	20144
1971	27	1482	433	164	2112	600	677	5743	3345	14584	14557	13075
1972	609	99	1201	234	123	1505	187	180	4613	8751	8141	8042
1973	1337	2073	146	1056	125	74	1198	62	2507	8579	7242	5169
1974	354	4382	1615	184	499	42	47	956	1564	9642	9288	4906
1975	396	1280	4624	1753	200	412	33	41	1916	10654	10258	8978
1976	6210	1442	1669	4060	1515	183	303	24	1505	16910	10700	9258
1977	691	22572	2013	1963	2913	1174	173	217	1199	32916	32225	9653
1978	464	2533	26826	2561	1803	2160	714	153	1099	38313	37849	35316
1979	6006	1699	3523	21910	2484	1373	1302	420	986	39703	33697	31998
1980	714	21909	2513	4357	16064	1626	813	582	1034	49613	48898	26989
1981	528	2602	17794	2844	4184	10376	1071	378	1209	40986	40458	37856
1982	236	1909	3288	14308	2369	2984	6809	632	1228	33762	33526	31618
1983	284	864	2225	2903	10428	1850	1905	4093	1219	25771	25487	24623
1984	1830	1037	1160	2035	2158	6570	1247	1407	3567	21011	19181	18144
1985	181	6672	1459	1177	1580	1509	3482	613	2782	19455	19273	12601
1986	1838	580	8461	1344	1453	1341	1483	2388	2661	21549	19711	19131
1987	232	5544	728	8010	1215	670	863	727	3414	21403	21171	15627
1988	1528	588	6713	1281	4620	776	444	489	3084	19522	17994	17406
1989	53	6076	642	5477	944	3237	499	282	2020	19232	19178	13102
1990	347	370	8639	866	4728	557	1895	455	1901	19759	19412	19041
1991	238	1287	457	9752	821	3411	332	1467	1732	19497	19259	17972
1992	967	969	1251	408	7102	684	2152	147	2104	15784	14817	13848
1993	1466	3093	1341	1130	255	3473	418	999	1468	13643	12177	9084
1994	1213	4582	5243	941	503	185	2026	310	1417	16419	15206	10624
1995	486	4577	7436	5314	751	398	65	1227	1299	21555	21069	16491
1996	770	2282	6911	7696	4669	583	320	52	2181	25462	24692	22410
1997	2217	2303	2927	6881	6635	3476	323	190	1405	26359	24141	21838
1998	872	7338	3759	3472	6560	5520	2950	342	1338	32151	31279	23941
1999	3532	3141	10058	3490	2780	5474	4059	2235	1054	35824	32291	29151
2000	1025	12107	5113	12365	3608	2835	4793	3333	2464	47644	46619	34512
2001	7189	3795	18051	5502	10288	2932	2512	3939	4570	58777	51588	47793
2002	334	20899	4570	14962	4202	7735	1913	1620	5802	62036	61702	40803
2003	210	1055	43388	4898	13425	3240	5812	1384	4999	78410	78200	77145
2004	20621	661	1821	46458	4597	9548	2004	3386	4106	93203	72582	71921
2005	187	57486	852	1289	36528	3107	5641	885	5683	111658	111471	53985
2006	1580	939	83976	914	1145	24930	2321	3996	4956	124757	123177	122238
2007	534	5414	1816	123872	1090	1426	16911	1643	5511	158217	157684	152270
2008	1479	1875	10315	2786	126331	960	907	11233	5594	161480	160001	158126

Table 24. Partial recruitment of haddock normalized to ages 4 to 8 from the eastern Georges Bank Canadian commercial fishery during 1991-2007.

	Age Group								
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**
1991	0.029	0.762	0.467	1.044	0.547	0.880	1.670	1.000	0.342
1992	0.012	0.316	0.643	0.767	1.066	0.626	0.977	1.000	0.304
1993	0.012	0.080	0.697	1.089	1.038	1.031	0.383	1.000	0.328
1994	0.010	0.108	0.564	1.049	0.834	2.928	0.766	1.000	0.313
1995	0.011	0.066	0.536	0.961	1.279	1.262	0.803	1.000	0.304
1996	0.004	0.042	0.388	0.925	1.103	1.797	1.036	1.000	0.734
1997	0.015	0.196	0.197	0.874	1.130	1.135	0.906	1.000	0.692
1998	0.018	0.109	0.636	0.696	1.055	1.316	0.812	1.000	0.718
1999	0.008	0.052	0.551	0.981	0.934	0.985	1.127	1.000	0.583
2000	0.005	0.097	0.582	1.099	0.941	0.921	0.718	1.000	0.543
2001	0.002	0.057	0.624	0.872	0.975	1.301	1.225	1.000	0.826
2002	0.002	0.036	0.245	0.979	0.905	1.172	0.853	1.000	0.890
2003	0.011	0.018	0.225	0.396	1.108	1.523	1.247	1.195	0.759
2004	0.005	0.060	0.196	0.679	1.335	2.030	3.979	2.026	1.108
2005	0.006	0.003	0.064	0.498	1.034	0.990	0.978	1.026	0.272
2006	0.002	0.007	0.040	0.117	0.929	1.092	0.665	1.056	0.298
2007	0.018	0.056	0.801	0.857	2.859	4.178	2.707	2.858	1.243
Avg 1999-02	0.017	0.068	0.524	1.000	1.005	1.084	1.069	1.083	0.731
Avg 2003-07	0.008	0.029	0.265	0.509	1.453	1.963	1.915	1.632	0.736

Table 25. Partial recruitment of haddock normalized to ages 5 to 8 from the eastern Georges Bank Canadian commercial fishery during 1991-2007.

	Age Group								
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**
1991	0.033	0.858	0.526	1.176	0.616	0.991	1.881	1.126	0.385
1992	0.011	0.310	0.631	0.753	1.046	0.614	0.959	0.981	0.298
1993	0.012	0.082	0.715	1.117	1.064	1.058	0.393	1.026	0.336
1994	0.010	0.110	0.579	1.076	0.856	3.004	0.786	1.026	0.321
1995	0.009	0.058	0.470	0.843	1.122	1.107	0.704	0.877	0.267
1996	0.004	0.036	0.336	0.800	0.954	1.554	0.895	0.865	0.634
1997	0.014	0.175	0.176	0.777	1.005	1.009	0.806	0.839	0.615
1998	0.016	0.098	0.573	0.626	0.950	1.185	0.731	0.900	0.647
1999	0.008	0.051	0.547	0.975	0.927	0.979	1.120	0.994	0.580
2000	0.005	0.110	0.660	1.248	1.069	1.046	0.815	1.136	0.617
2001	0.002	0.054	0.592	0.828	0.926	1.236	1.163	0.950	0.785
2002	0.002	0.035	0.237	0.947	0.876	1.134	0.826	0.968	0.861
2003	0.009	0.015	0.183	0.331	0.928	1.275	1.044	1.000	0.635
2004	0.003	0.030	0.097	0.335	0.659	1.002	1.964	1.000	0.547
2005	0.006	0.003	0.063	0.486	1.008	0.966	0.954	1.000	0.265
2006	0.002	0.007	0.038	0.111	0.876	1.030	0.627	0.997	0.281
2007	0.006	0.020	0.285	0.305	1.016	1.485	0.962	1.015	0.442
Avg 1999-02	0.018	0.071	0.542	1.026	1.022	1.113	1.073	1.106	0.741
Avg 2003-07	0.005	0.015	0.134	0.313	0.897	1.151	1.110	1.002	0.434

Table 26. Lengths estimated for the eastern Georges Bank haddock 2003 year class based on growth rates from the 1998, 1999 and 2000 year classes for input into the catch projection and risk assessment for 2009.

Age	Beginning year length (cm)	Growth rate	Calculated length for following year[2]
5	45.7[1]	0.079	49.4
6	49.4	0.046	51.8
7	51.8	-	-

[1]Observed 2008 beginning year length for 2003 year class from the Canadian Department of Fisheries and Oceans survey

[2] $length_{a+1} = length_a \times e^{growth\ rate}$

Table 27. Lengths and weights for eastern Georges Bank haddock from the 2008 Canadian Department of Fisheries and Oceans survey compared to weights estimated by the relationship between length and weight (LW) derived by Waiwood and Nielson (1985).

Age	2008 Survey Lengths	Observed (kg)	LW equation (kg)	% difference
1	23.1	0.107	0.149	72
2	33.1	0.329	0.426	77
3	39.4	0.573	0.708	81
4	43.0	0.795	0.915	87
5	45.7	0.927	1.097	85
6	50.5	1.254	1.468	85
7	56.3	1.729	2.014	86
8	52.9	1.476	1.675	88

Table 28. Beginning year and fishery lengths and weights estimated for the eastern Georges Bank haddock 2003 year class for input into the risk assessment for 2009.

Age	Beginning of year			Fishery	
	Length	Weight[2]	- 10%[3]	Length	Weight[2]
5	45.7[1]	0.927[1]	N/A	51.3[5]	1.533
6	49.4[4]	1.373	1.236	53.2[5]	1.705
7	51.8[4]	1.577	1.419		

[1]Observed 2008 beginning year length or weight for 2003 year class from the Canadian Department of Fisheries and Oceans (DFO) survey

[2] $weight = 0.0000158 \times length^{2.91612}$ *(Waiwood and Neilson 1985)*

[3]Weight reduced by 10% to reflect lower values for survey weights versus fishery weights

[4]Calculated length

[5]Estimated from relationship between beginning of year (DFO survey) and fishery lengths the same year.

Table 29. Input for projections and risk analyses of eastern Georges Bank haddock for the 2009 fishery. A catch of 23,000 mt in 2008 and natural mortality = 0.2 were assumed for the forecasts. Shaded values indicate the 2003 year class.

Year	Age Group								
	1	2	3	4	5	6	7	8	9+
Population Numbers (000s)									
2008	13823	5700	17994	3506	136236	766	524	7613	2949
Partial Recruitment to the Fishery[1]									
2008	0.01	0.01	0.1	0.3	0.58[2]	1	1	1	0.4
2009	0.01	0.01	0.1	0.3	0.9	0.83[2]	1	1	0.4
Weight at beginning of year for population (kg)									
2008[3]	0.11	0.33	0.57	0.8	0.93	1.25	1.73	1.48	1.9
2009[4]	0.08	0.25	0.46	0.72	0.93	1.24[5]	1.63	1.63	2.04
2010[4]	0.08	0.25	0.46	0.72	0.93	1.46	1.42[5]	1.63	2.04
Weight at age for catch (kg)[6]									
2008	0.40	0.60	0.99	1.2	1.53[7]	1.77	1.91	1.91	2.18
2009	0.40	0.60	0.99	1.2	1.56	1.71[7]	1.91	1.91	2.18
Maturity									
2008	0	0	1	1	1	1	1	1	1
2009	0	0	1	1	1	1	1	1	1
2010	0	0	1	1	1	1	1	1	1

[1]Average of 2003 to 2007 except where indicated
[2]Derived from relationship between fishery weights at for age 1995 to 2007 and partial recruitment values
[3]2008 Canadian Department of Fisheries and Oceans (DFO) survey average weights at age
[4]Average of 2006 to 2008 DFO survey average weights at age except where indicated
[5]Estimated weights based on a growth model for the 2003 year class and reduced by 10% to reflect lower condition
[6]Average of 2005 to 2007 Canadian fishery weights at age
[7]Estimated weights based on a growth model for the 2003 year class

Table 30. Bias adjusted deterministic projection results for eastern Georges Bank haddock for the 2009 fishery using 20 million recruits for the 2008 and 2009 year classes and assuming that the 2008 quota of 23,000 mt is caught. Shaded values indicate the 2003 year class.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
Population Numbers (000s)												
2008	13823	5700	17994	3506	136236	766	524	7613	2949	189111		
2009	20000	11296	4658	14460	2714	100104	520	356	7413	161521		
2010	20000	16332	9224	3716	10951	1758	66050	328	5695	134054		
Population Biomass (mt)												
2008	1479	1875	10311	2787	126291	960	907	11237	5594	161441	159962	158087
2009	1620	2813	2124	10411	2524	123728	846	580	15108	159754	158134	155322
2010	1620	4067	4206	2675	10184	2559	93724	535	11606	131176	129556	125490
Fishing mortality												
2008	0.002	0.002	0.019	0.056	0.108	0.187	0.187	0.187	0.075			
2009	0.003	0.003	0.026	0.078	0.234	0.216	0.26	0.26	0.104			
Projected Catch Numbers (000s)												
2008	23	10	301	173	12684	118	81	1178	192	14760		
2009	47	27	108	985	515	17674	108	74	665	20203		
Catch Biomass (mt)												
2008	9	6	297	208	19445	209	155	2252	419	23000	22991	22985
2009	19	16	107	1182	802	30134	207	142	1448	34057	34038	34022

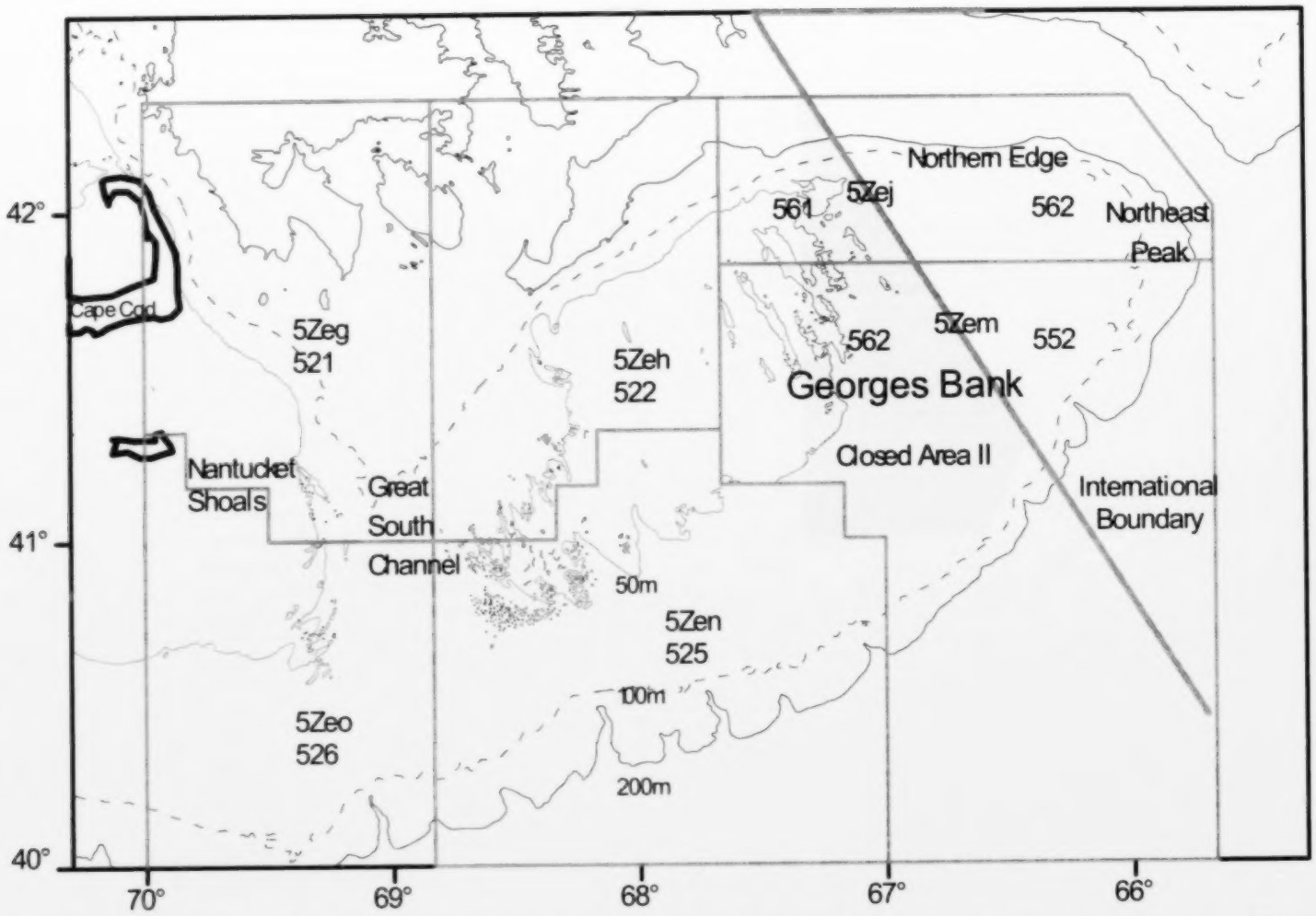


Figure 1. Fisheries statistical unit areas in North Atlantic Fisheries Organization Subdivision 5Ze. Alpha-numeric codes, e.g. 5Zej, are the Canadian Department of Fisheries and Oceans designations and numeric codes, e.g. 561, are National Marine Fisheries Service designations.

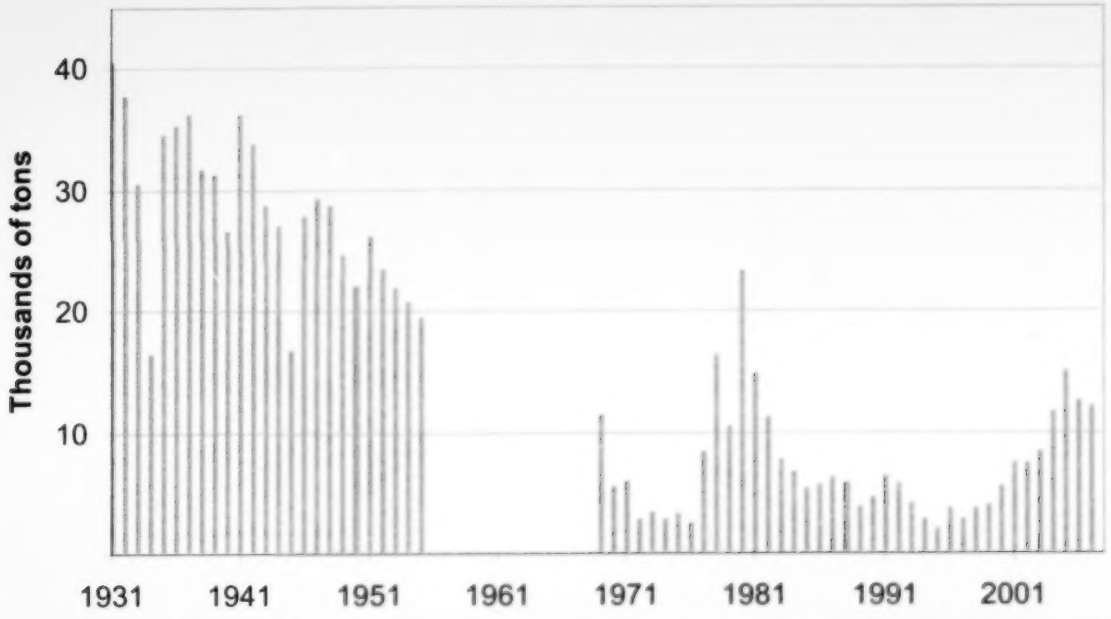


Figure 2. Historical catch of eastern Georges Bank haddock during 1931-1955 compared to recent catches during 1969-2007.

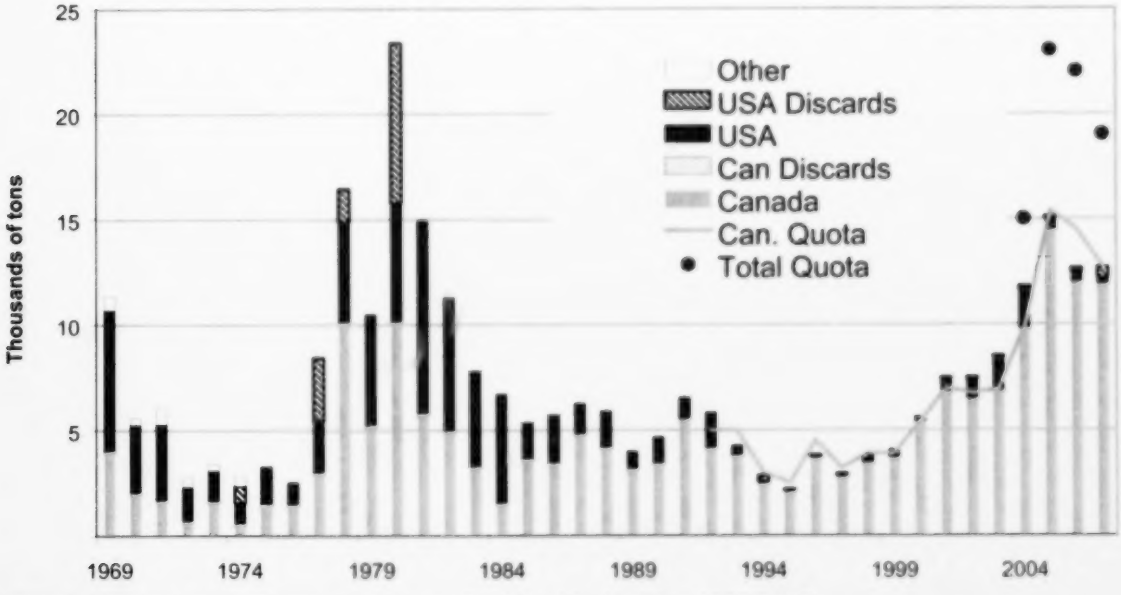


Figure 3. Nominal catch of eastern Georges Bank haddock during 1969-2007.

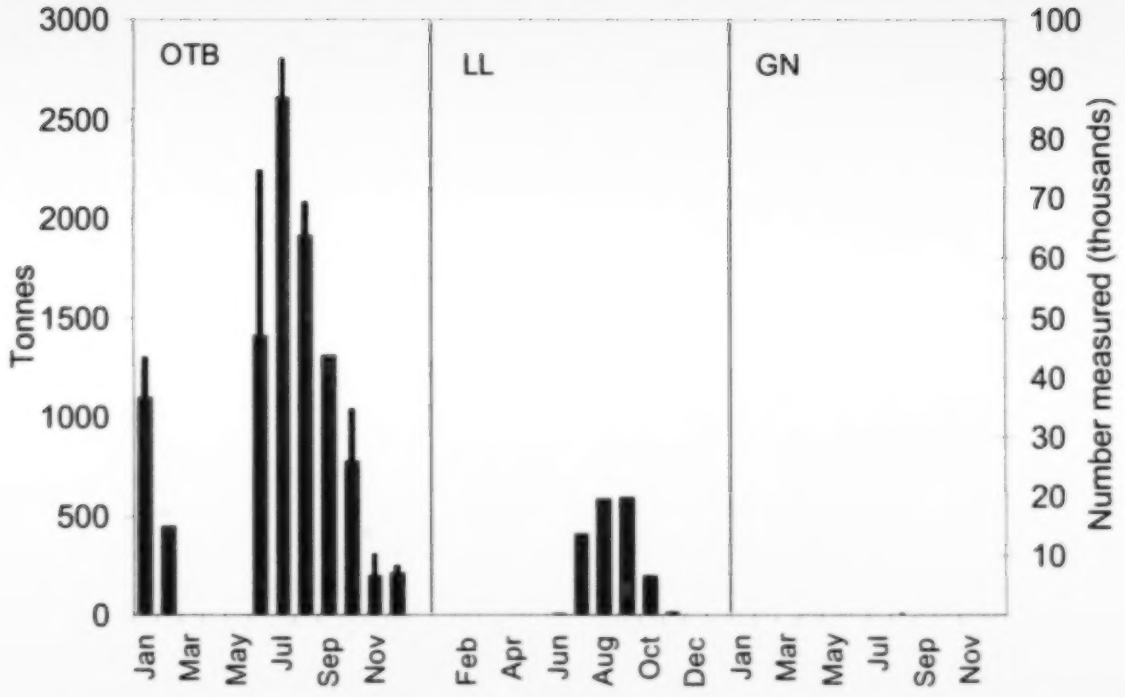
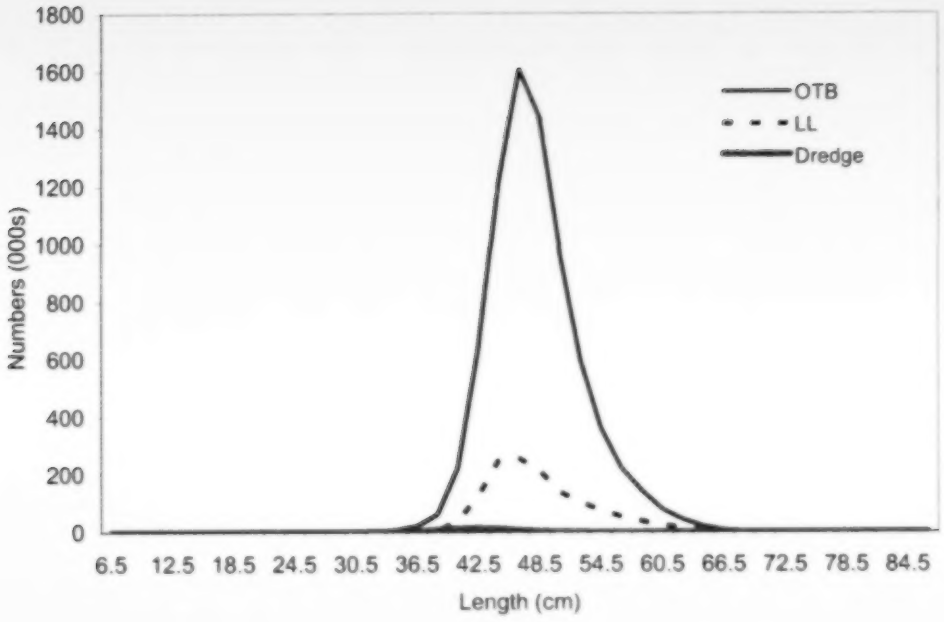


Figure 4. Haddock catches in eastern Georges Bank by month and gear for the Canadian commercial groundfish fishery in 2007 (wide bars) with sampling levels (narrow bars).



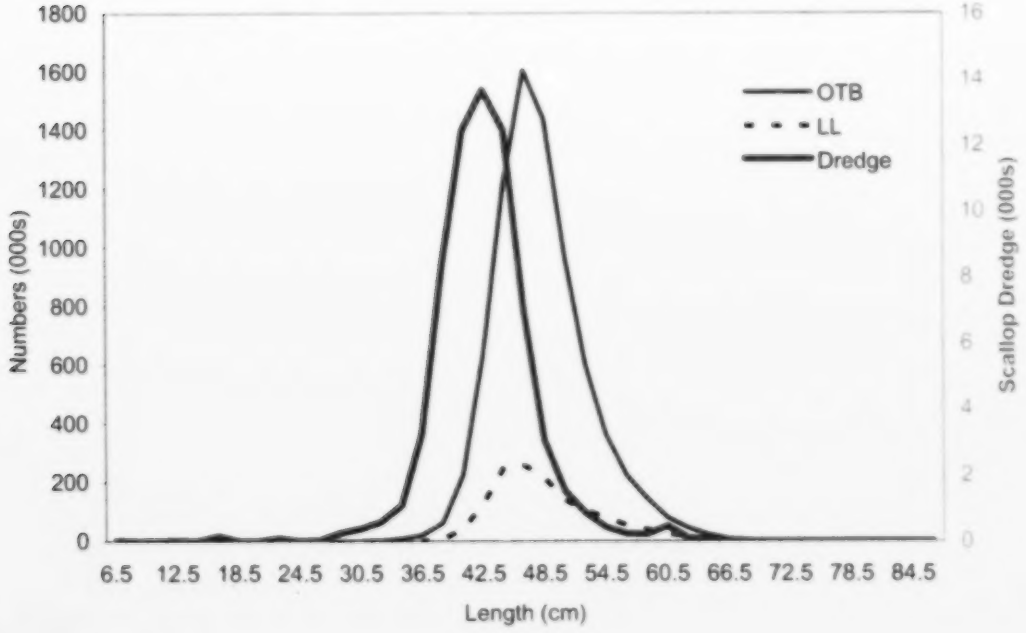


Figure 5. Catch at length by the principal Canadian eastern Georges Bank commercial haddock fisheries in 2007. In the lower graph the scallop dredge length frequency is expanded according to the axis on the right.

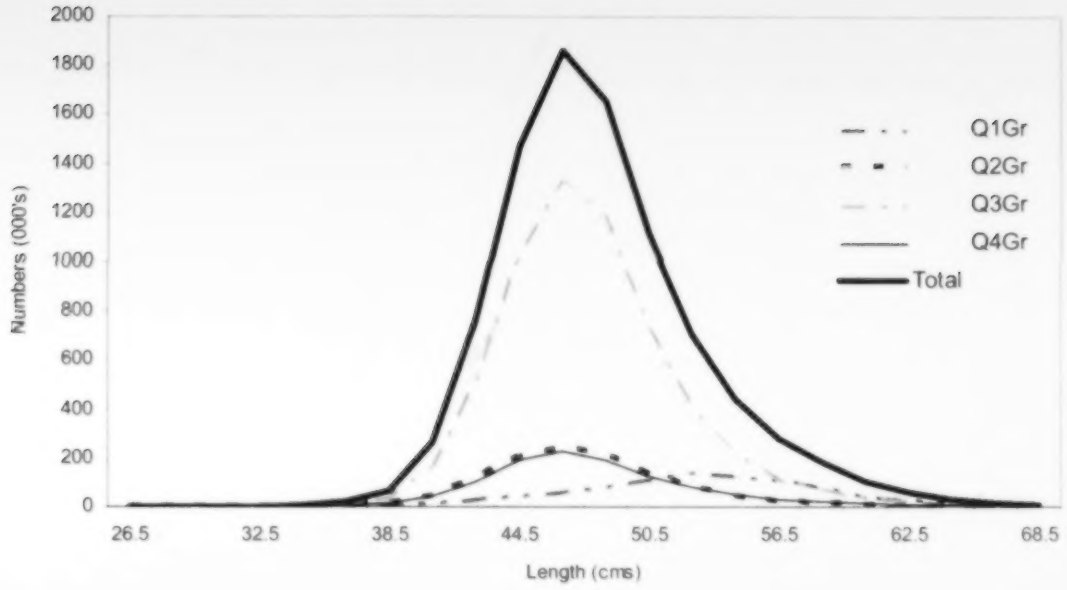


Figure 6. Catch at length by quarter for the Canadian eastern Georges Bank commercial haddock fisheries in 2007.

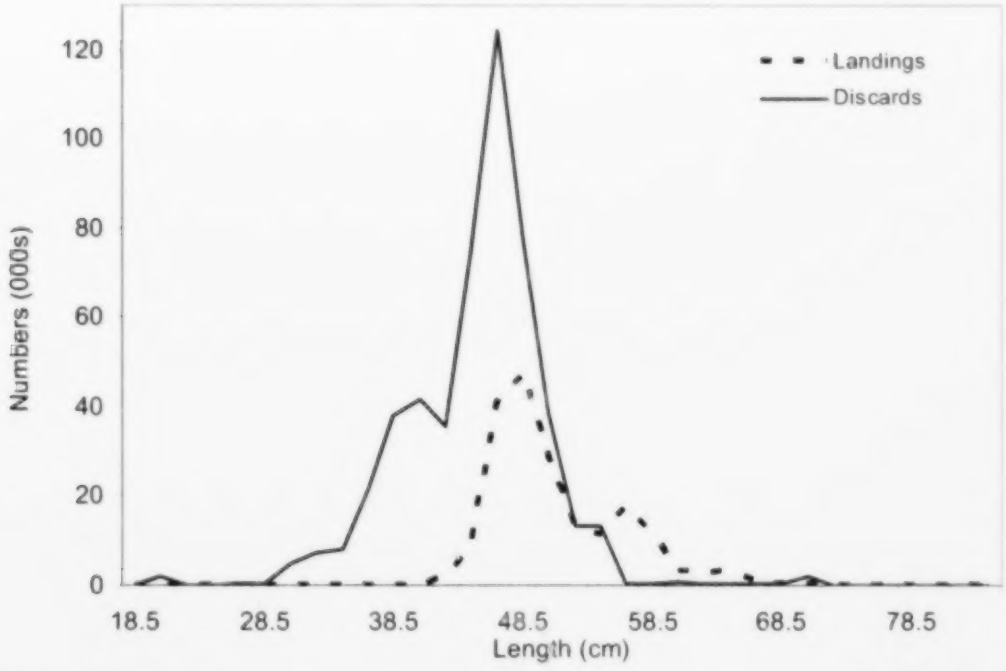


Figure 7. Catch at length of haddock by the United States eastern Georges Bank groundfish fisheries in 2007.

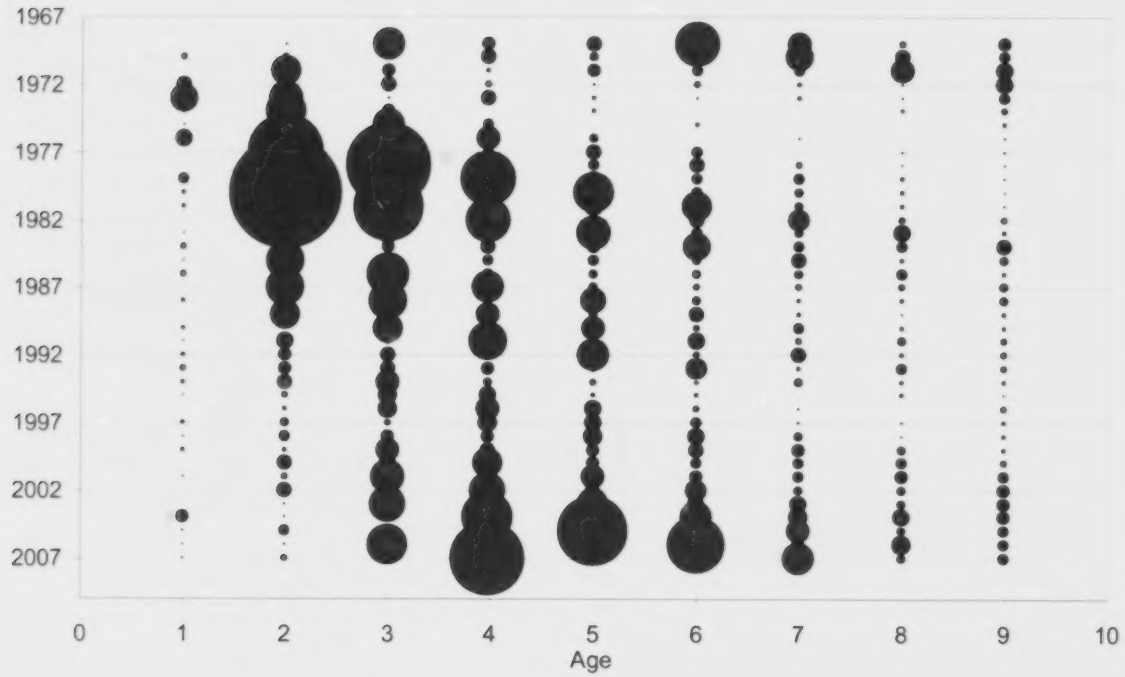


Figure 8. Total commercial catch at age (numbers) of eastern Georges Bank haddock during 1969-2007. The bubble area is proportional to magnitude.

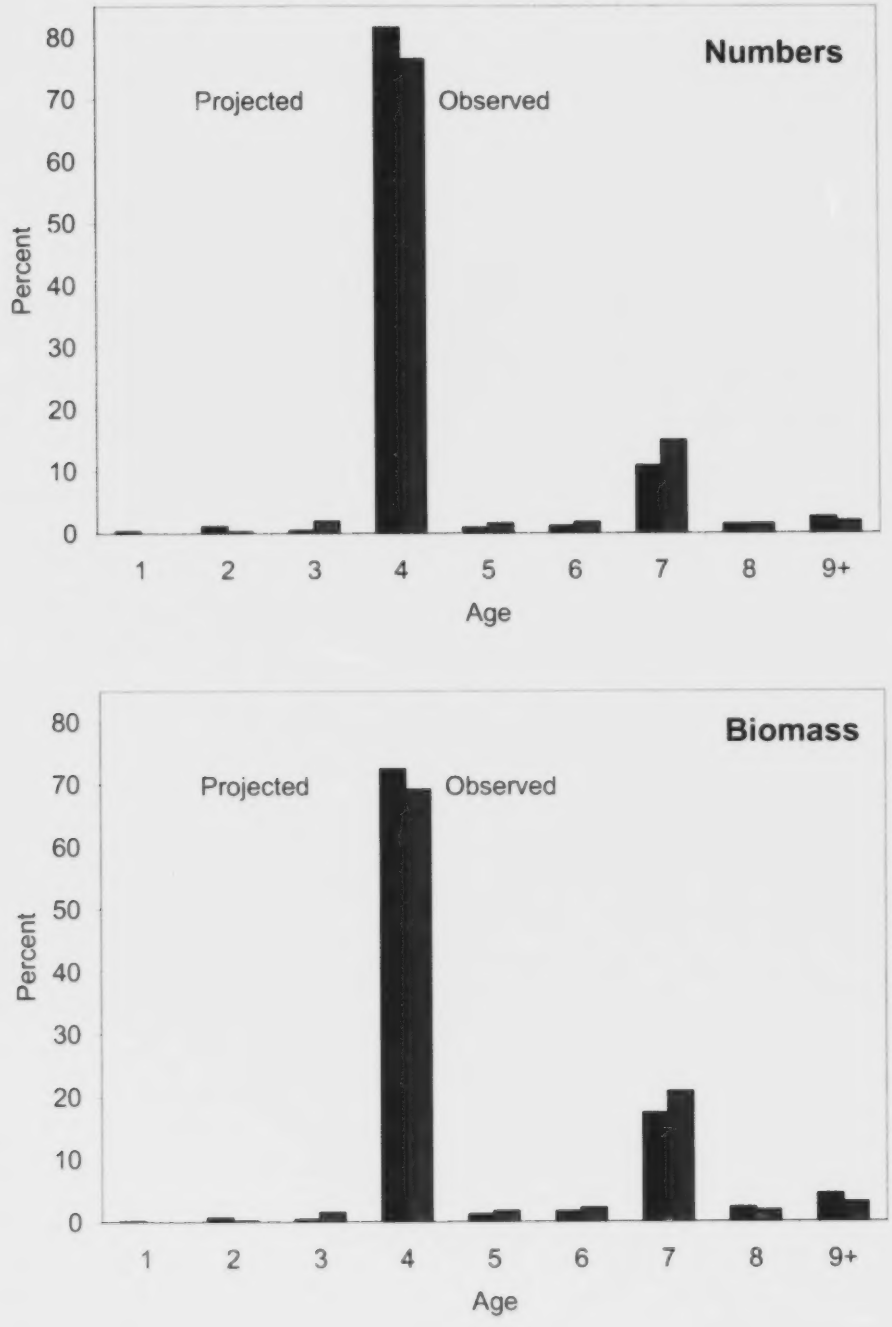


Figure 9. Actual and projected 2006 eastern Georges Bank haddock catch in percent composition.

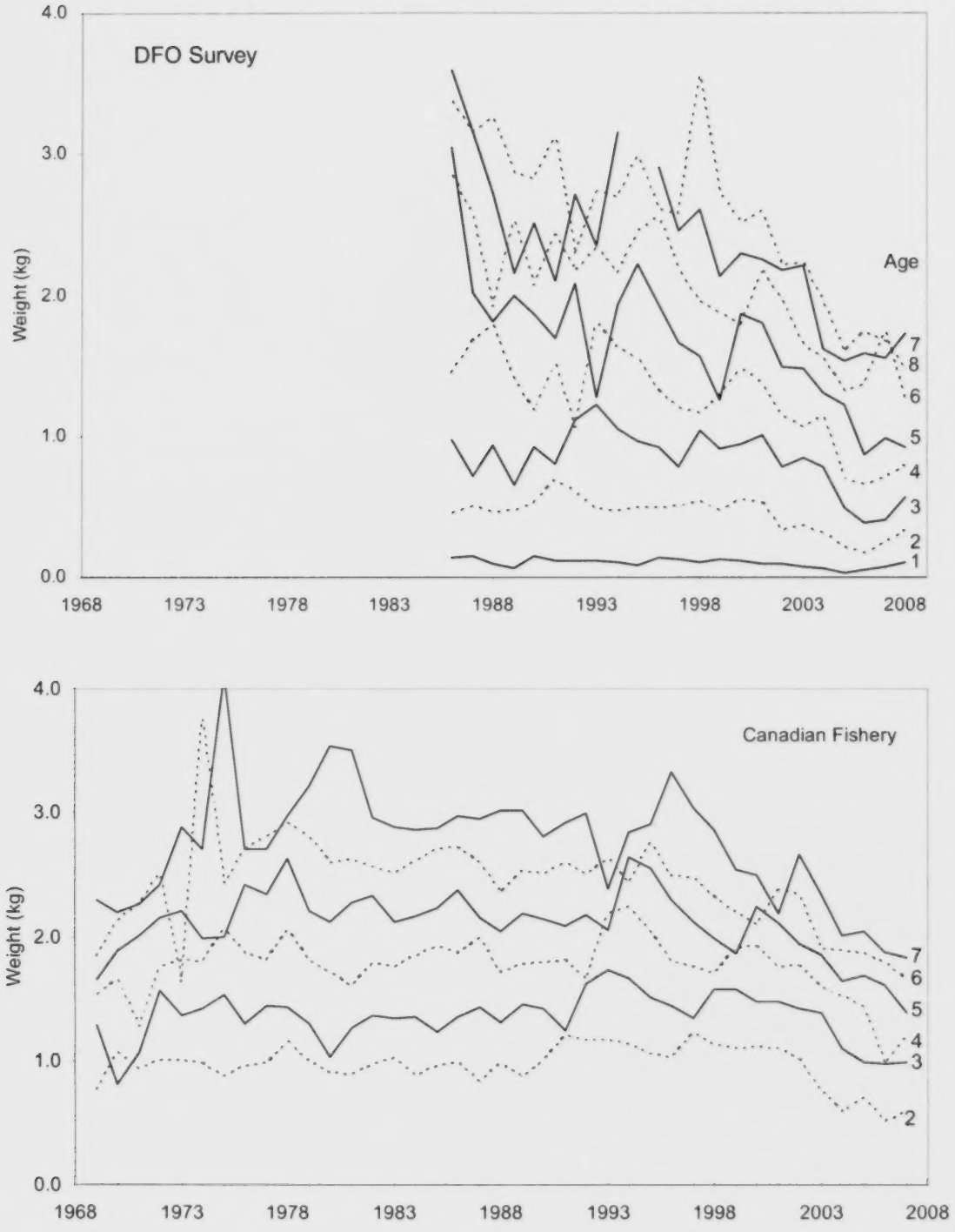


Figure 10. Average weights at age for eastern Georges Bank haddock from the Canadian commercial groundfish fishery during 1969-2007 and from the Canadian Department of Fisheries and Oceans survey during 1986-2008.

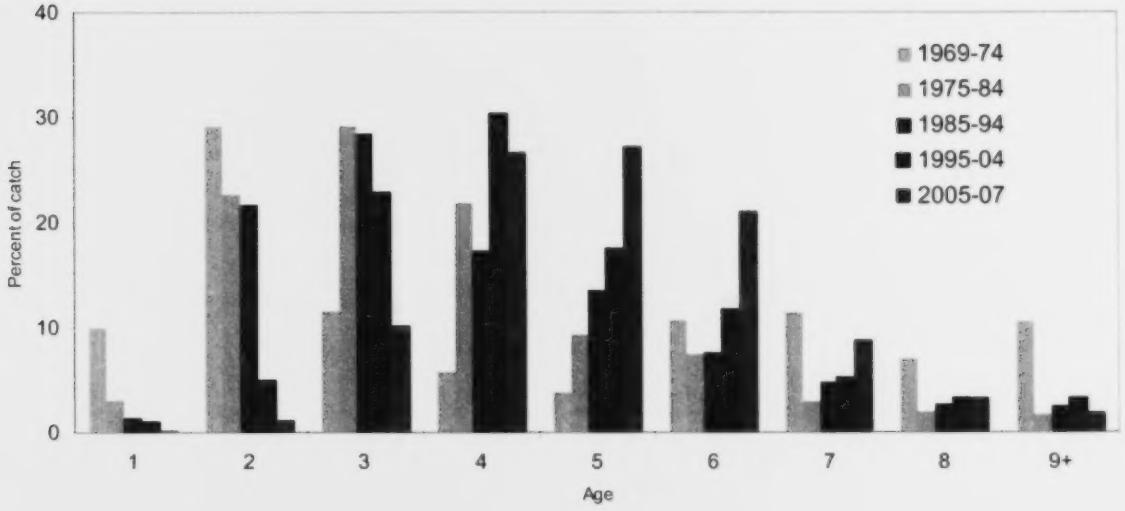


Figure 11. Age composition of the haddock catch for the eastern Georges Bank commercial fishery during 1969-1974, 1975-1984, 1985-1994, 1995-2004, and 2005-2007.

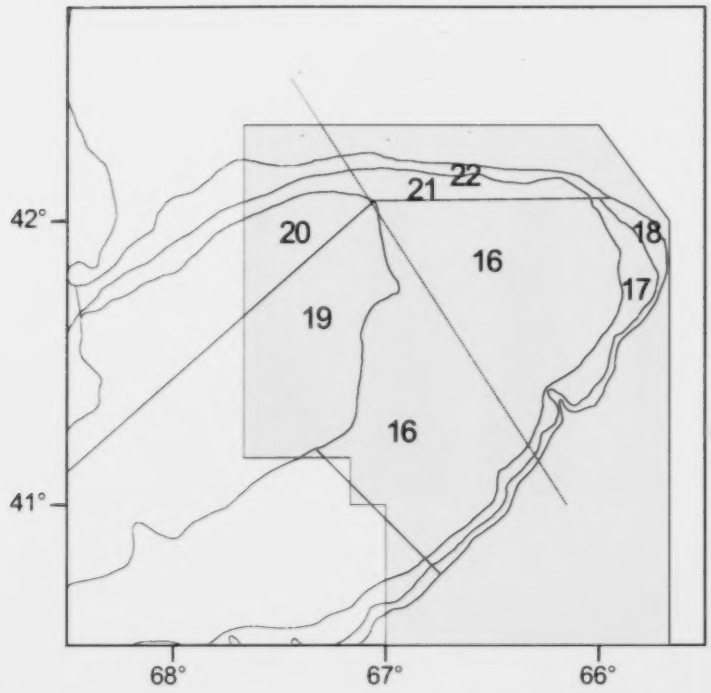


Figure 12. Stratification scheme used for National Marine Fisheries Service surveys. The eastern Georges Bank management area is indicated by shading.

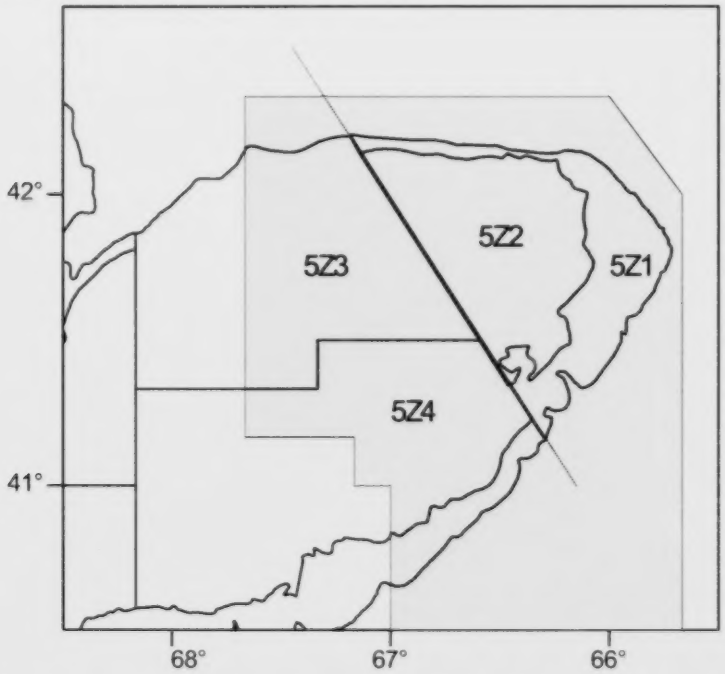


Figure 13. Stratification scheme used for the Canadian Department of Fisheries and Oceans survey. The eastern Georges Bank management area is indicated by shading.

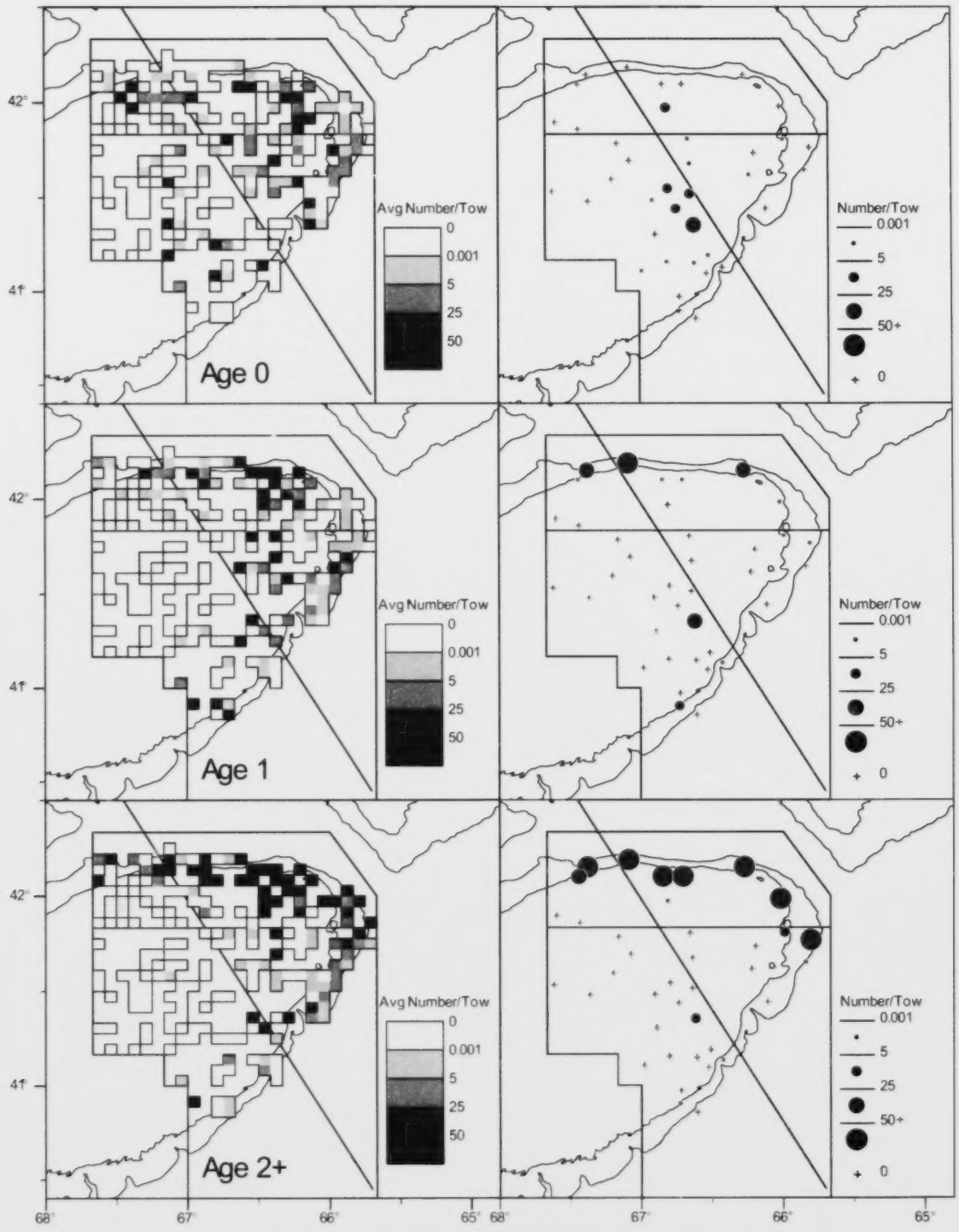


Figure 14. Distribution of eastern Georges Bank haddock abundance (number/tow) as observed from the National Marine Fisheries Service **fall** survey. The squares (left panels) are shaded relative to the average catch for 1997 to 2006. The expanding symbols (right panels) represent the **2007** survey catches

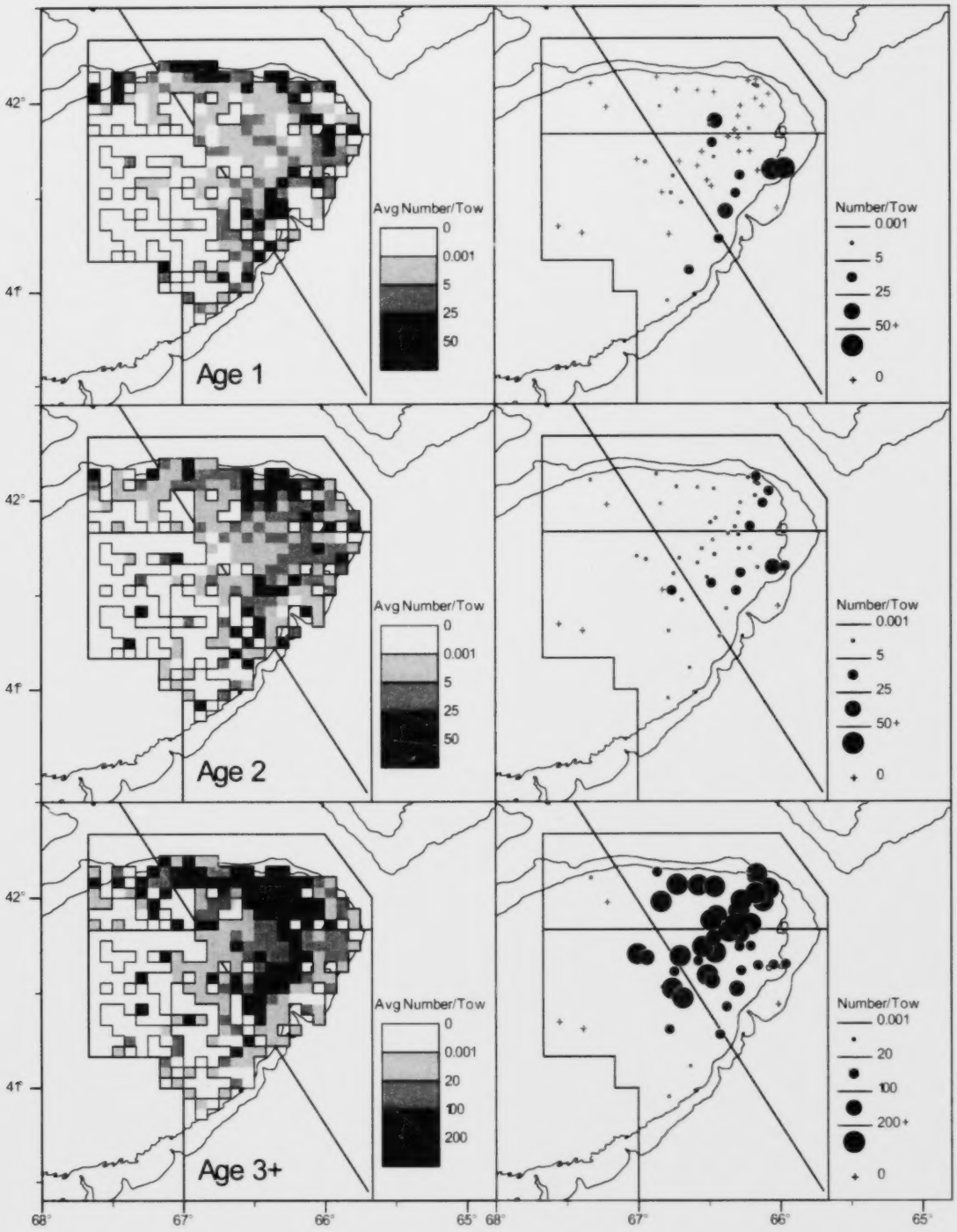


Figure 15. Distribution of eastern Georges Bank haddock abundance (number/tow) as observed from the Canadian Department of Fisheries and Oceans survey. The squares (left panels) are shaded relative to the average catch for 1998 to 2007. The expanding symbols (right panels) represent the **2008** survey catches.

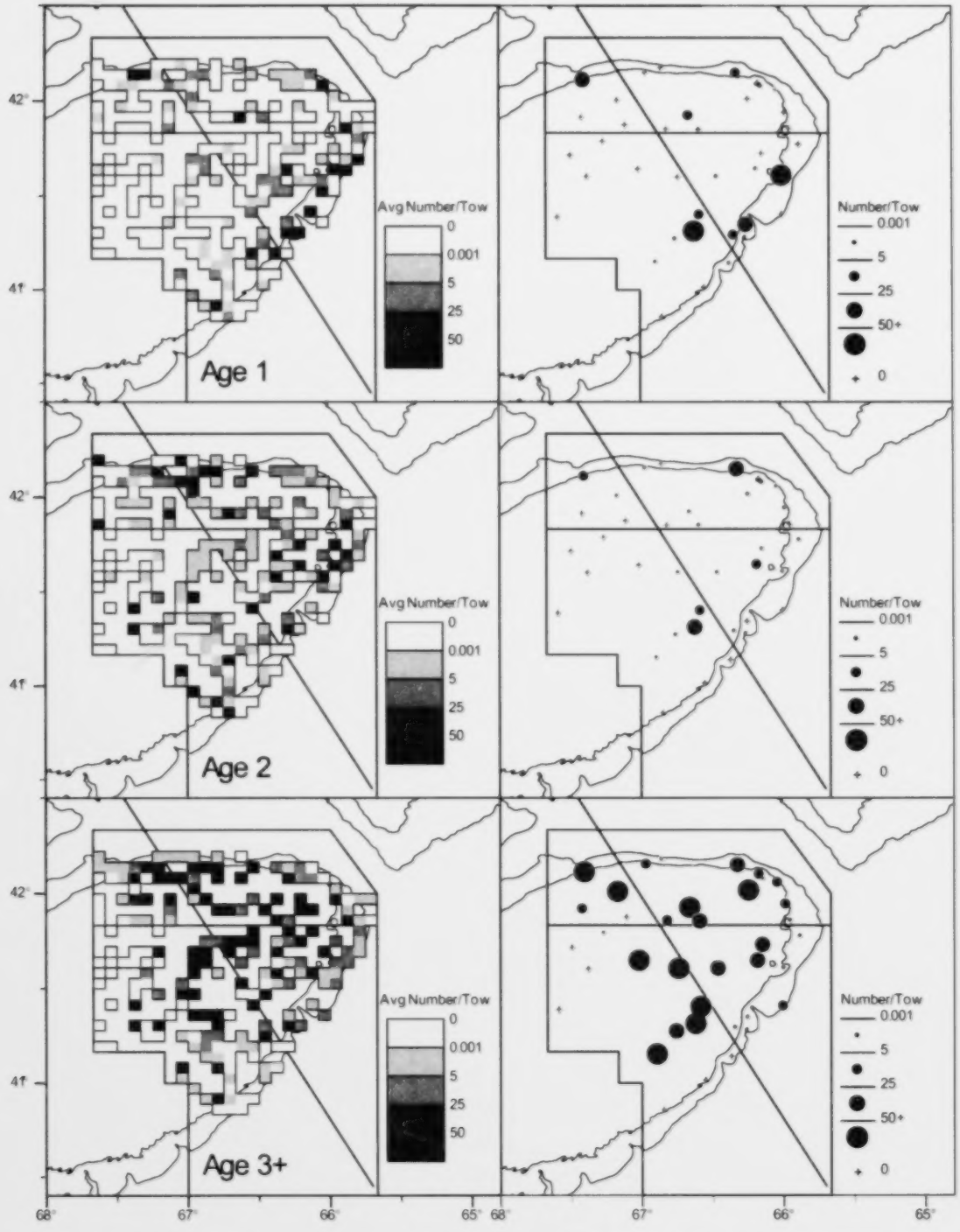


Figure 16. Distribution of eastern Georges Bank haddock abundance (number/tow) as observed from the National Marine Fisheries Service **spring** survey. The squares (left panels) are shaded relative to the average catch for 1998 to 2007. The expanding symbols (right panels) represent the **2008** survey catches.

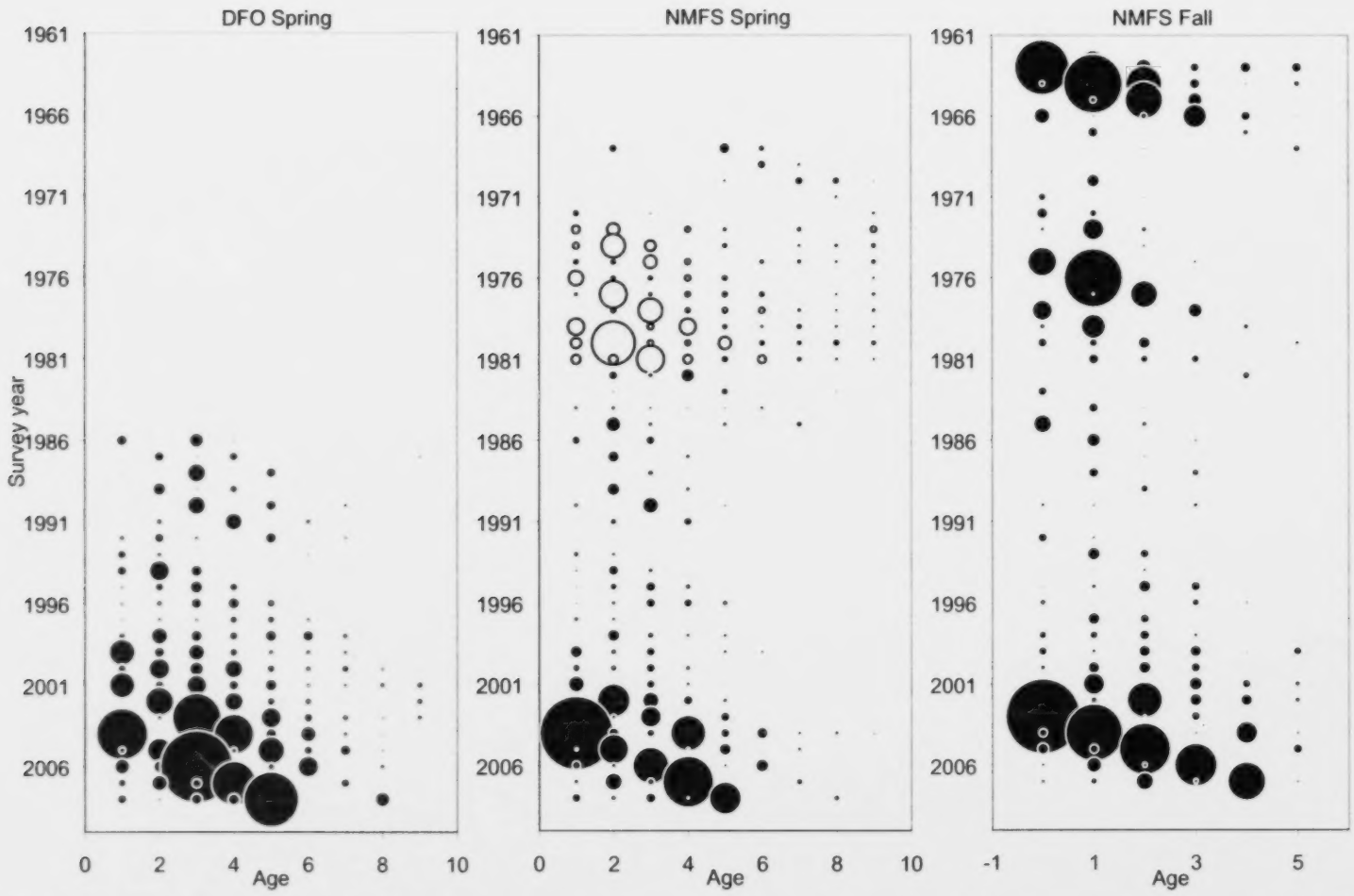


Figure 17. Estimated abundance at age (numbers in 000's) of eastern Georges Bank haddock for the Canadian Department of Fisheries and Oceans (DFO), National Marine Fisheries Service (NMFS) spring and NMFS fall surveys during 1963-2008. Bubble area is proportional to magnitude (see Tables 14-16). Conversion factors to adjust for changes in door type and survey vessel were applied to the NMFS surveys. From 1973-81 (pale circles), a 41 Yankee trawl was used for the NMFS spring survey while a 36 Yankee was used in the other years. Symbol size has not been adjusted between surveys for the catchability of the survey.

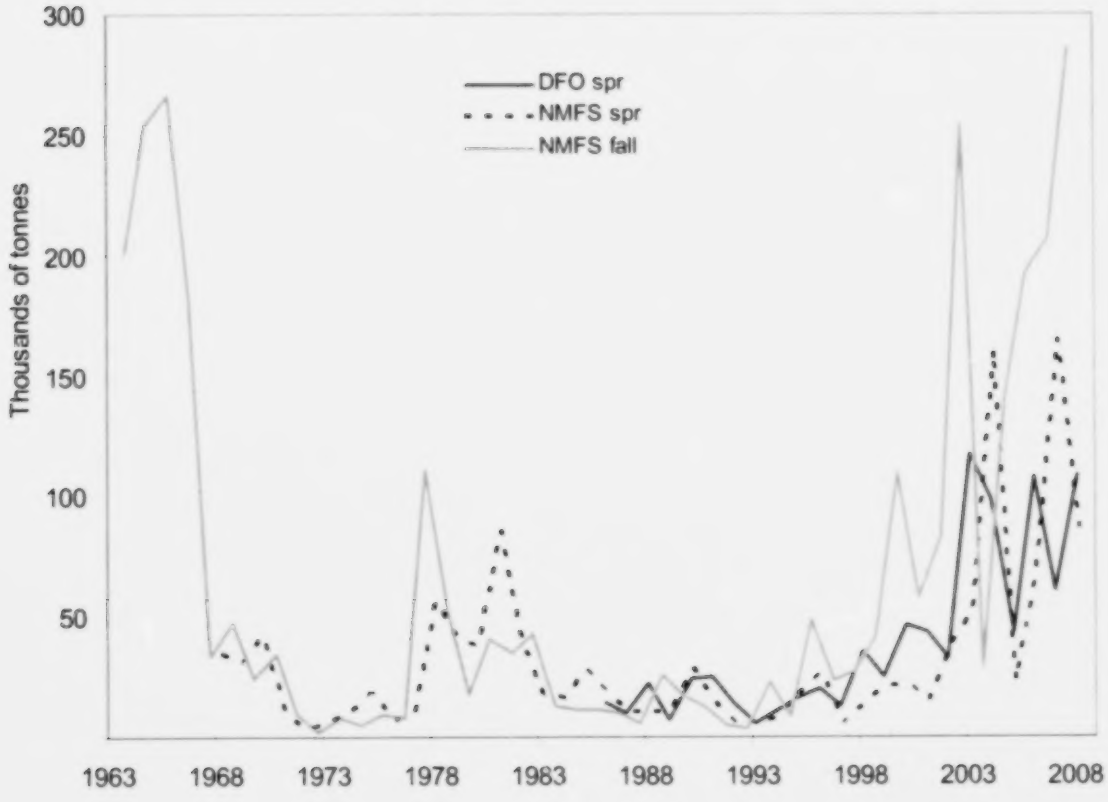


Figure 18. Biomass from National Marine Fisheries Service (NMFS) fall (ages 2-8), NMFS spring (ages 3-8) and Canadian Department of Fisheries and Oceans (DFO) (ages 3-8) research surveys (scaled by calibration constants) for eastern Georges Bank haddock during 1963-2008.

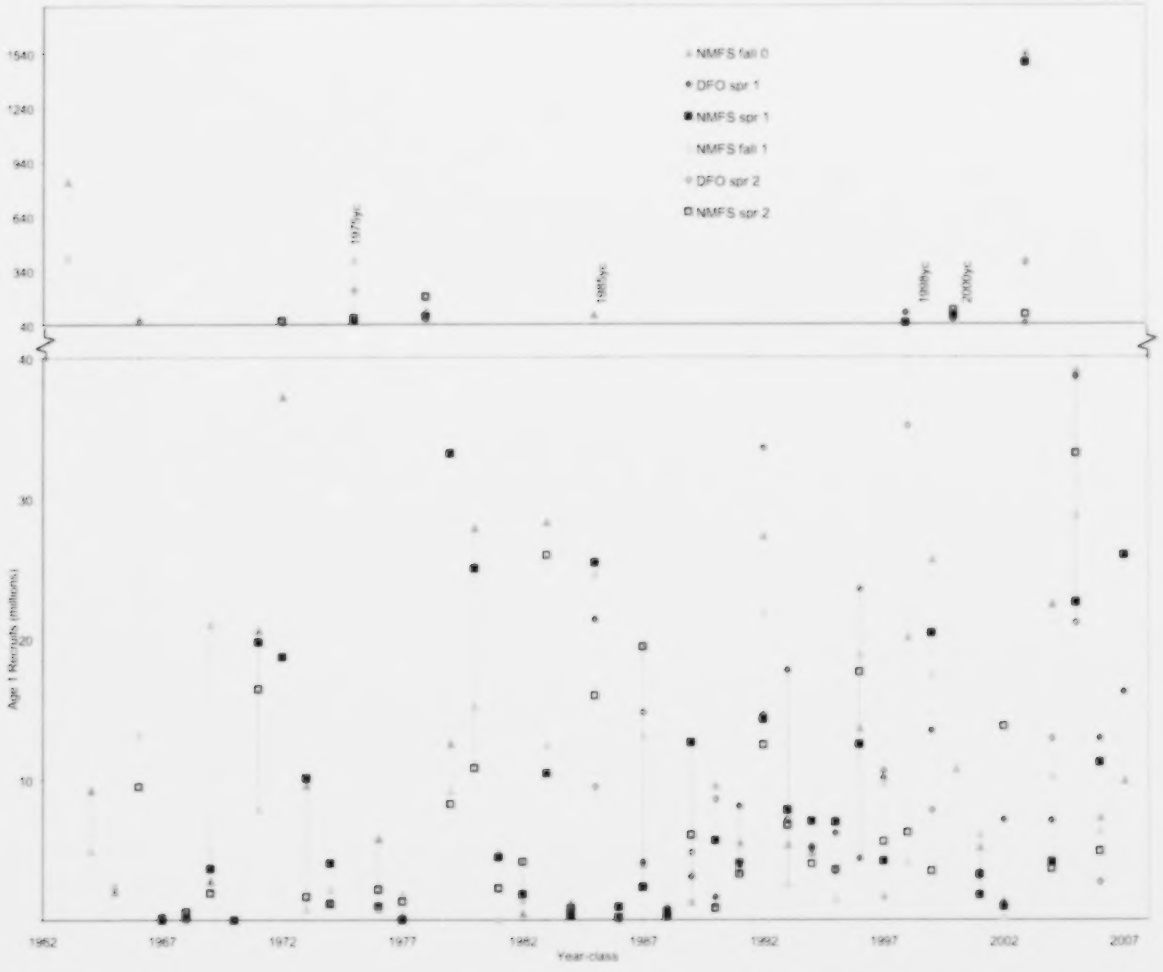


Figure 19. Year-class abundance for ages 0 and 1 from the National Marine Fisheries Service (NMFS) fall survey and ages 1 and 2 from the NMFS spring and Canadian Department of Fisheries and Oceans (DFO) research surveys (scaled by calibration constants) for eastern Georges Bank haddock during 1963-2008.

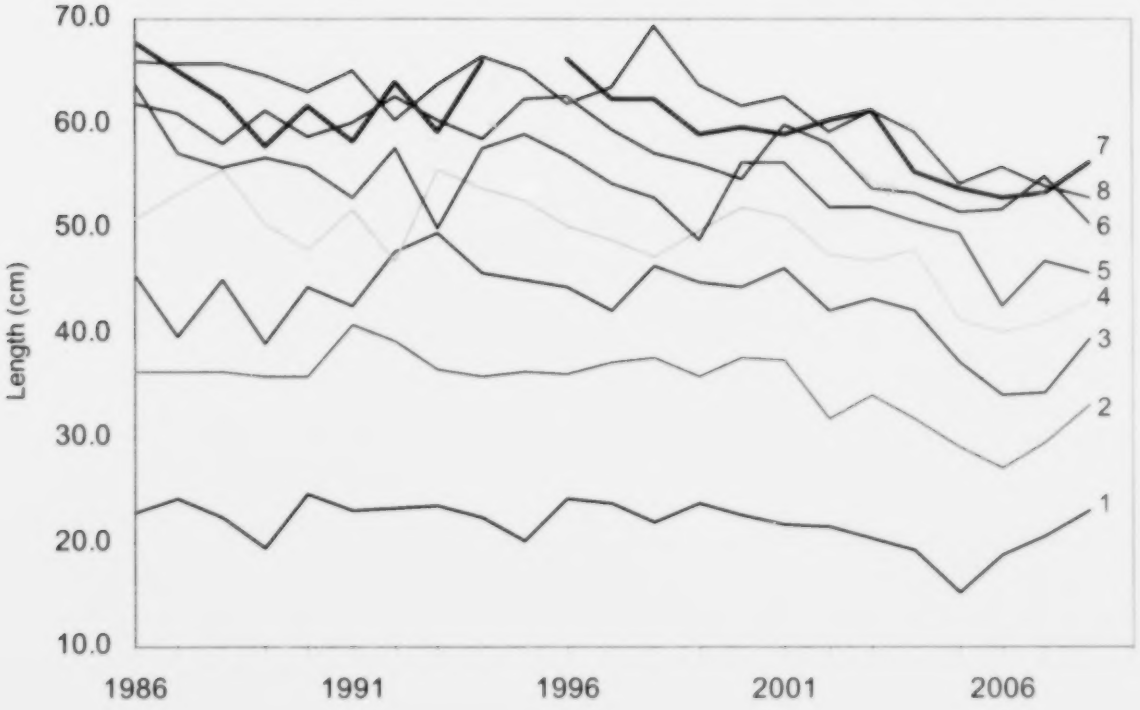


Figure 20. Length at age for eastern Georges Bank haddock derived from Canadian Department of Fisheries and Oceans surveys during 1986-2008.

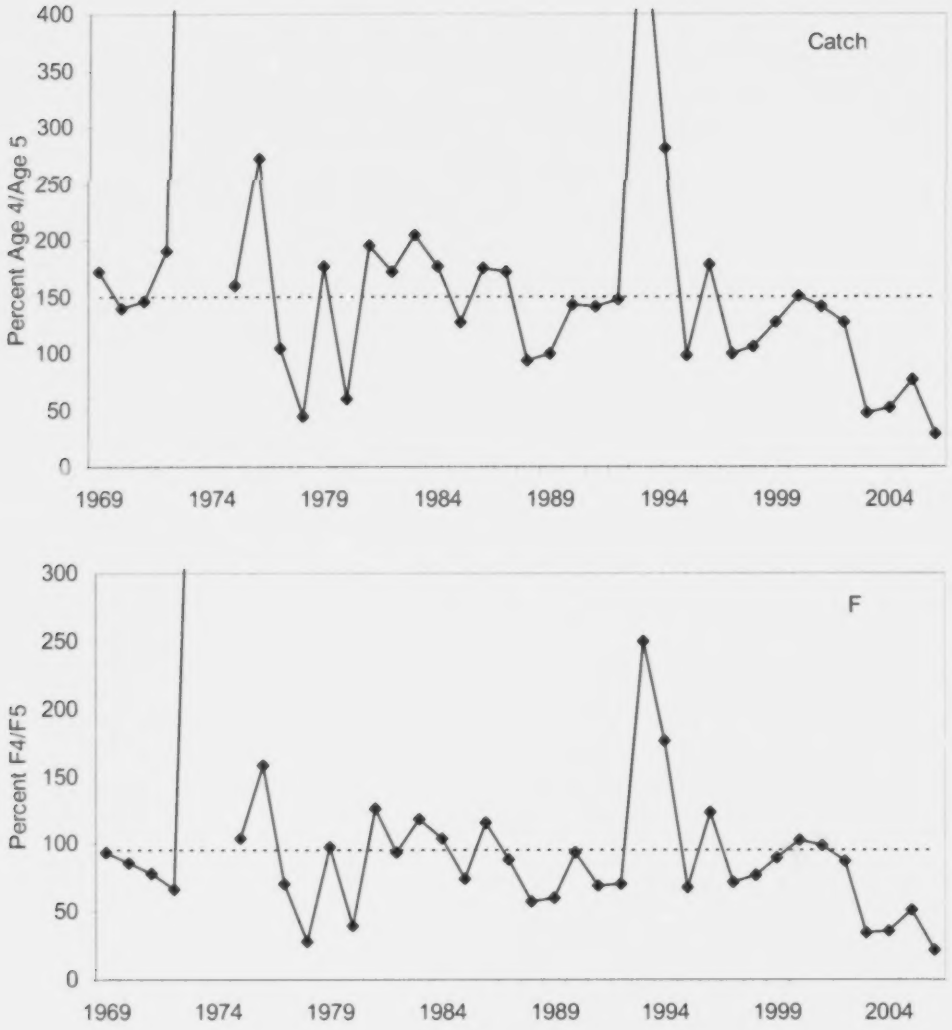


Figure 21. Relationship between Age 4 and Age 5 (from same year class) catch and fishing mortality (F) for eastern Georges Bank haddock for 1969 to 2006.

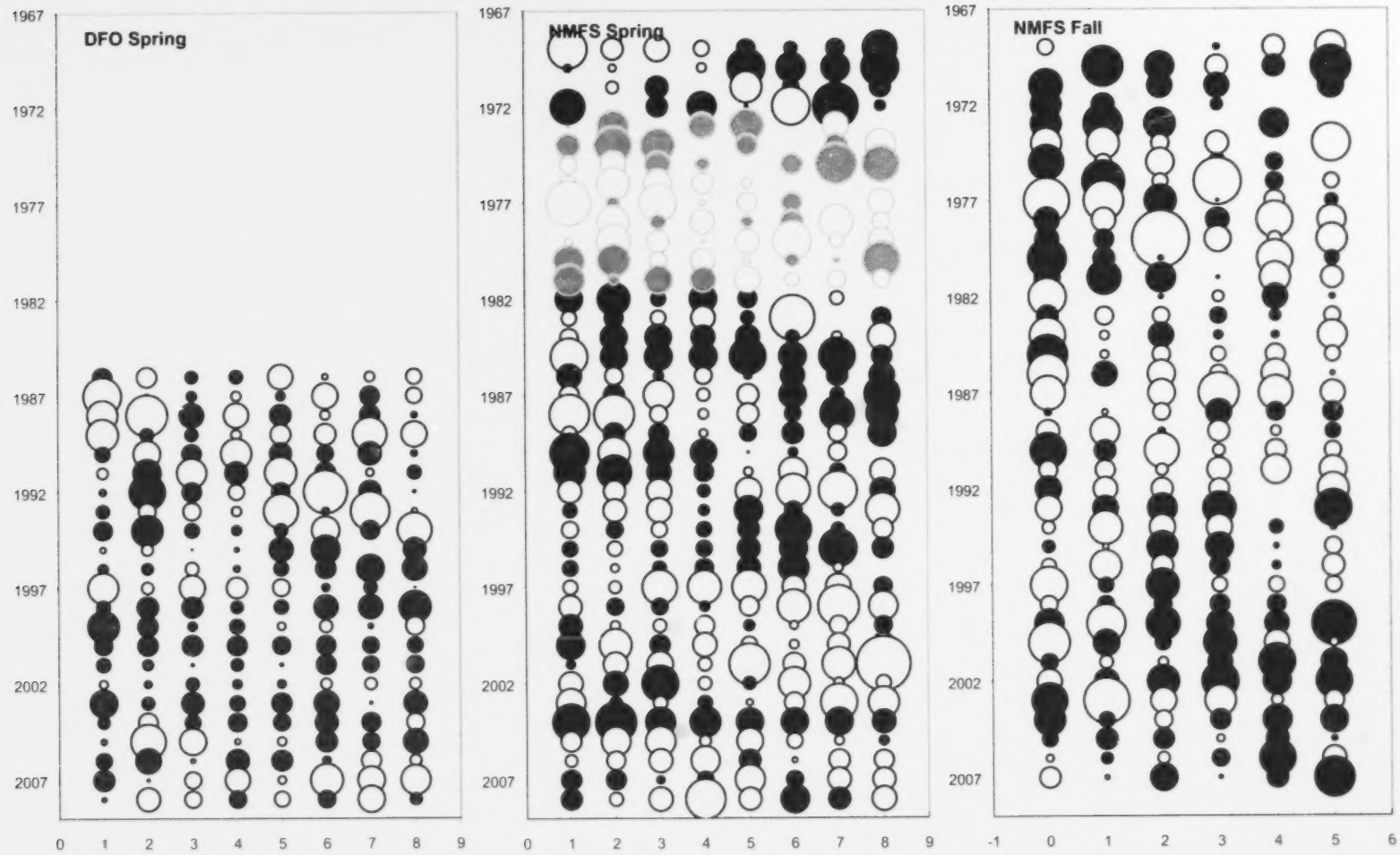


Figure 22. Residuals by year and age group for Canadian Department of Fisheries (DFO) and National Marine Fisheries Service (NMFS) research survey indices during 1969-2008 for eastern Georges Bank haddock. Solid symbols indicate positive values, open symbols indicate negative values. Bubble area is proportional to magnitude. From 1973-81 (pale circles), a 41 Yankee trawl was used for the NMFS spring survey while a 36 Yankee was used in the other years.

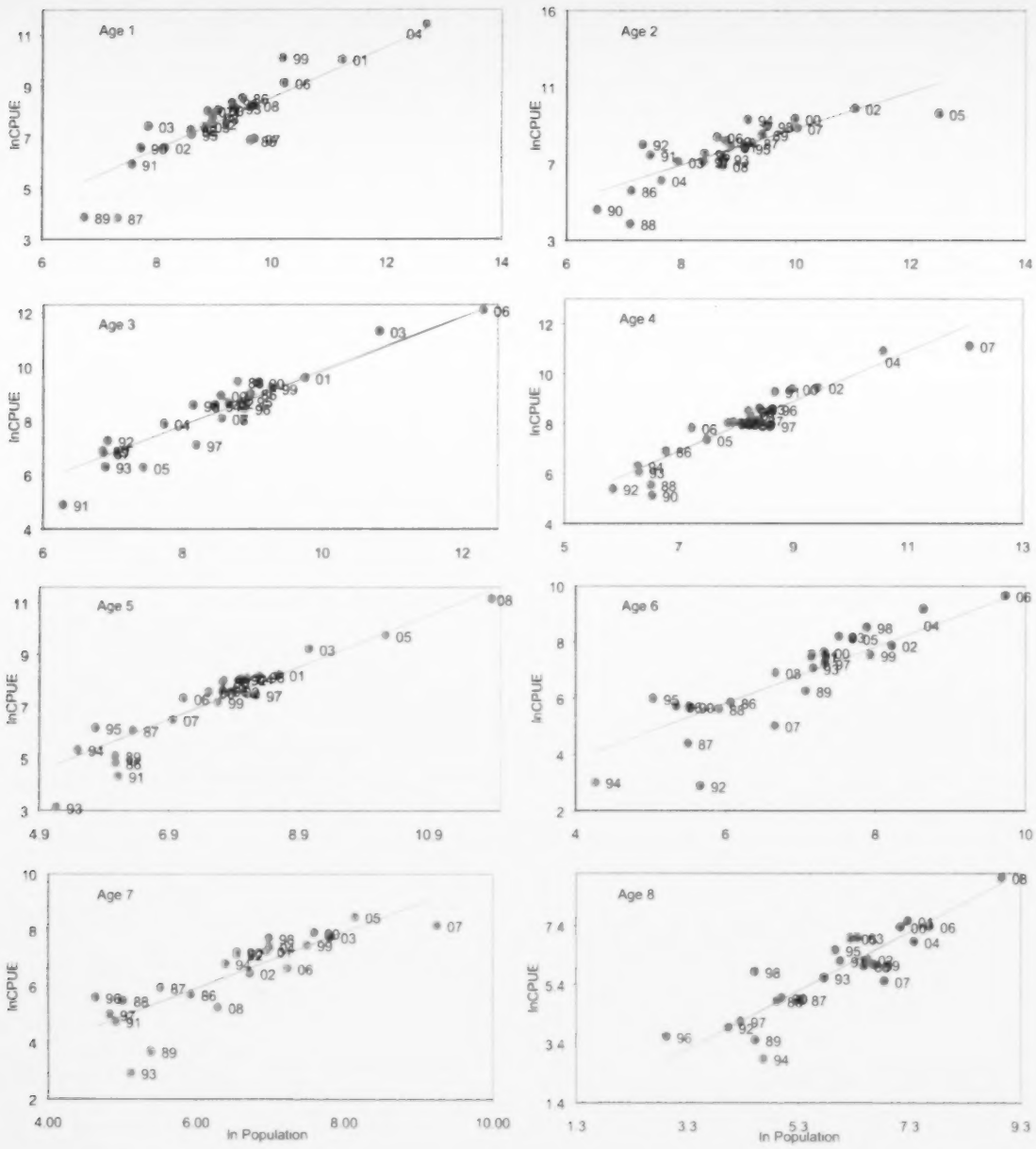


Figure 23. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for eastern Georges Bank haddock from the Department of Fisheries and Oceans survey during 1986-2008.

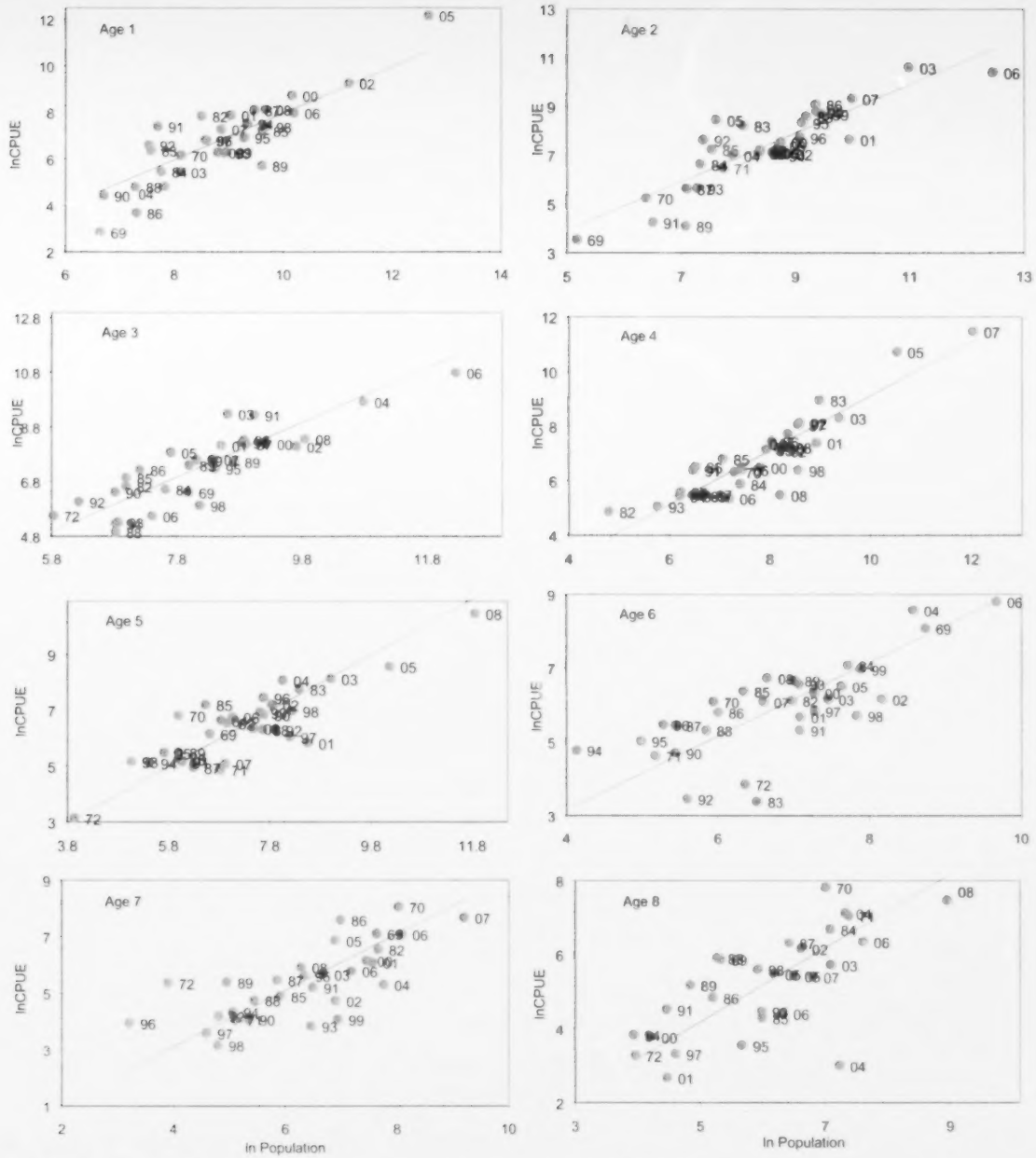


Figure 24. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for eastern Georges Bank haddock from the National Marine Fisheries Service **spring** survey with a Yankee 36 net during 1969-1972 and 1982-2008.

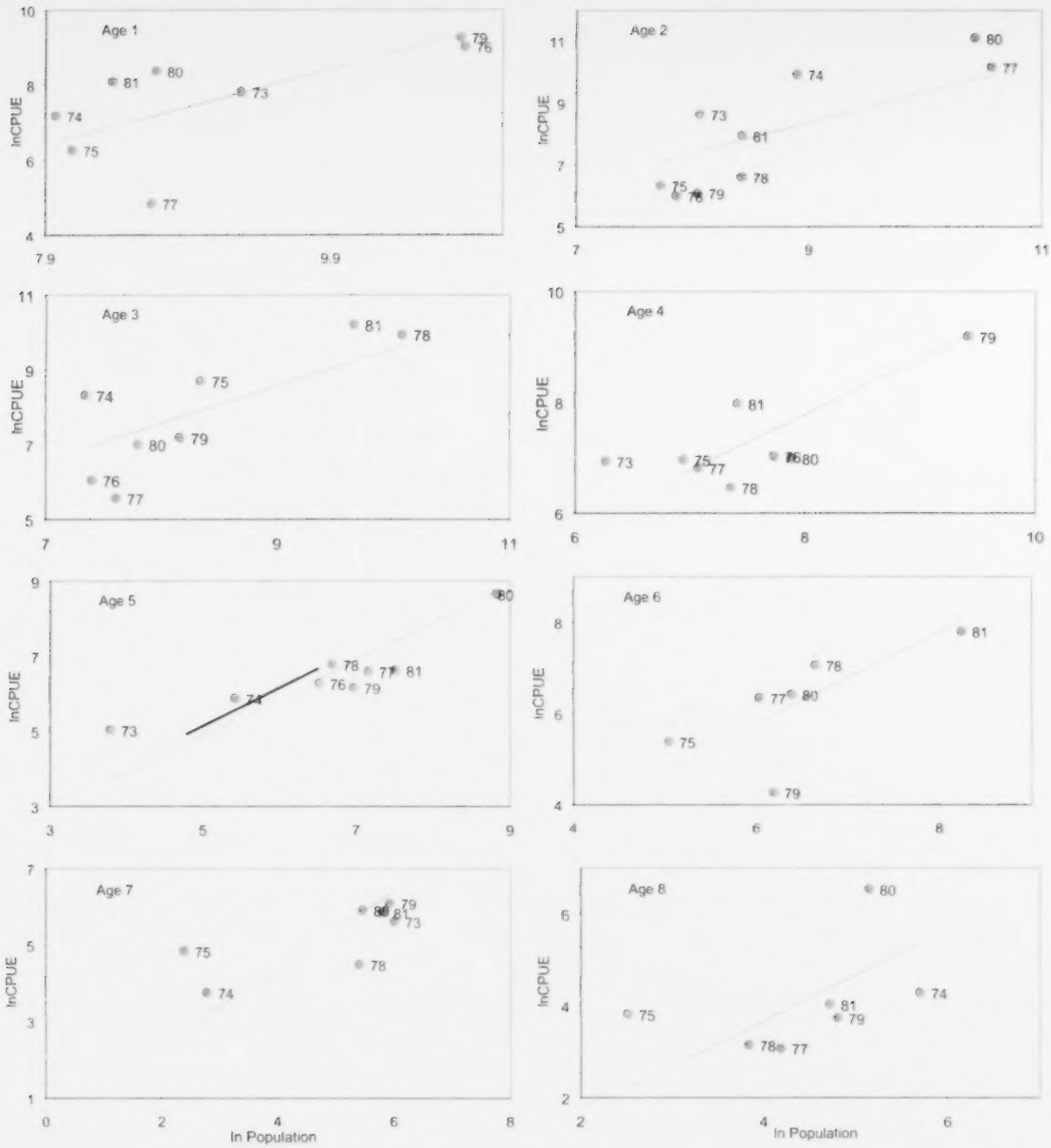


Figure 25. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for eastern Georges Bank haddock from the National Marine Fisheries Service **spring** survey with a Yankee 41 net during 1973-1981.

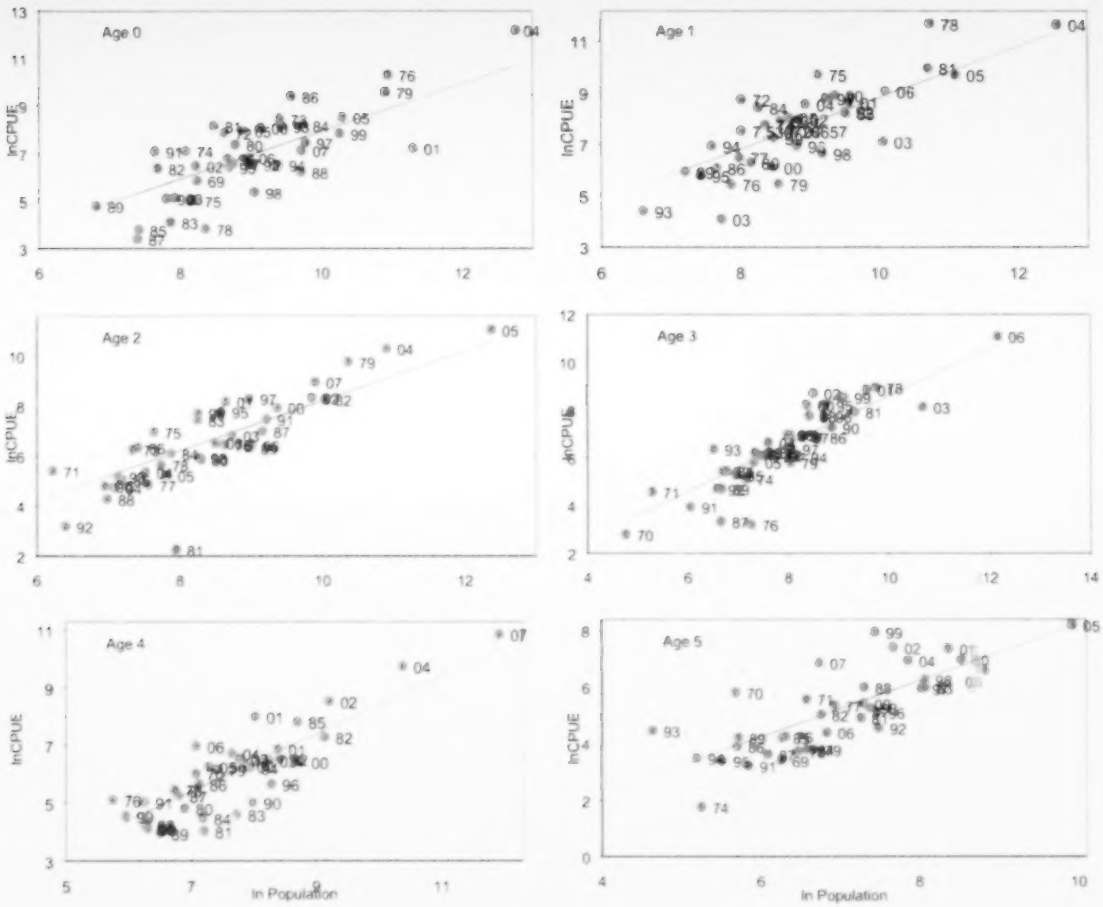


Figure 26. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for eastern Georges Bank haddock from the National Marine Fisheries Service **fall** survey 1969-2007.

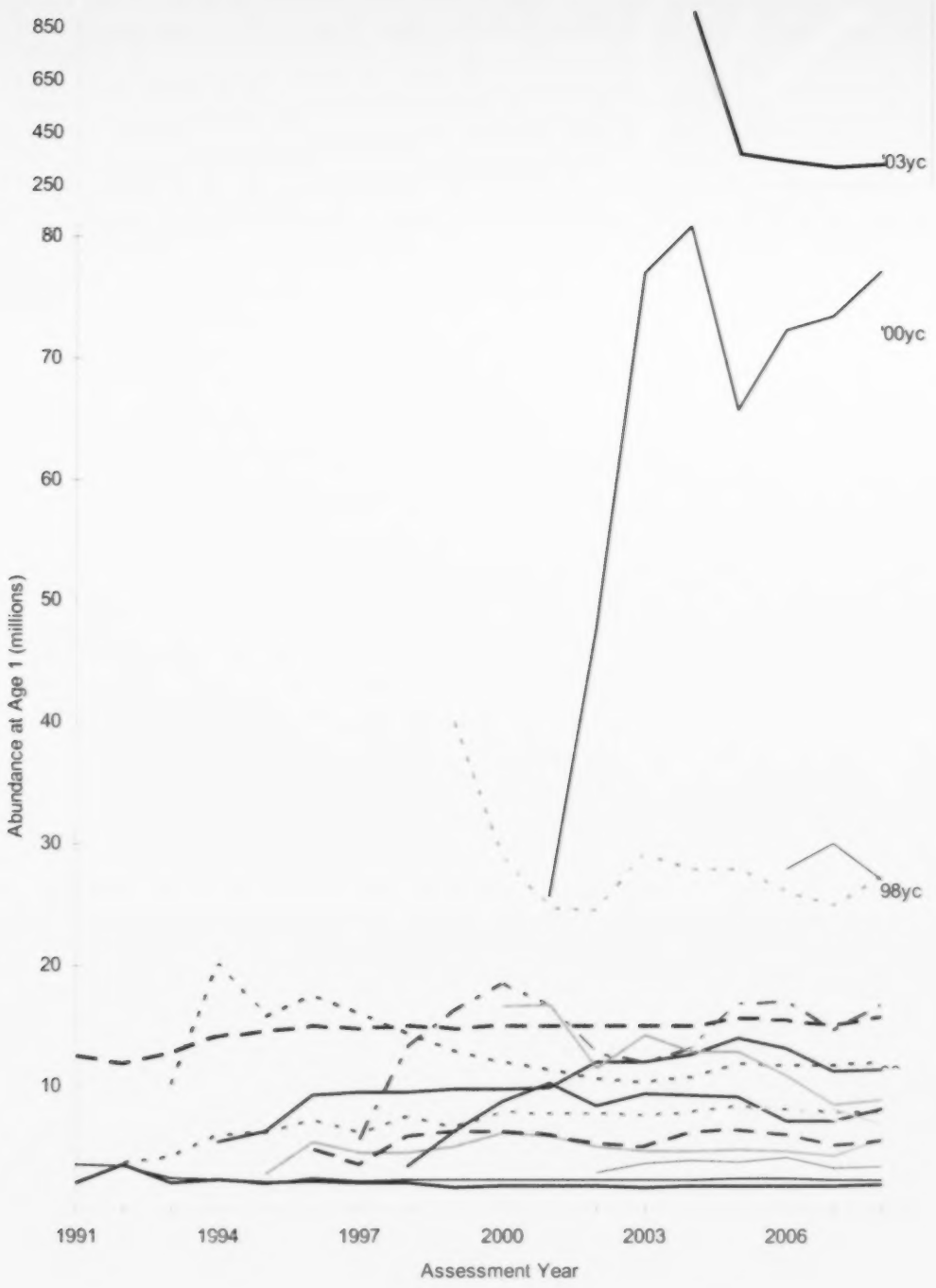


Figure 27. Retrospective estimates of eastern Georges Bank haddock year-class abundance as additional years of data were included in the assessment did not display any persistent trends.

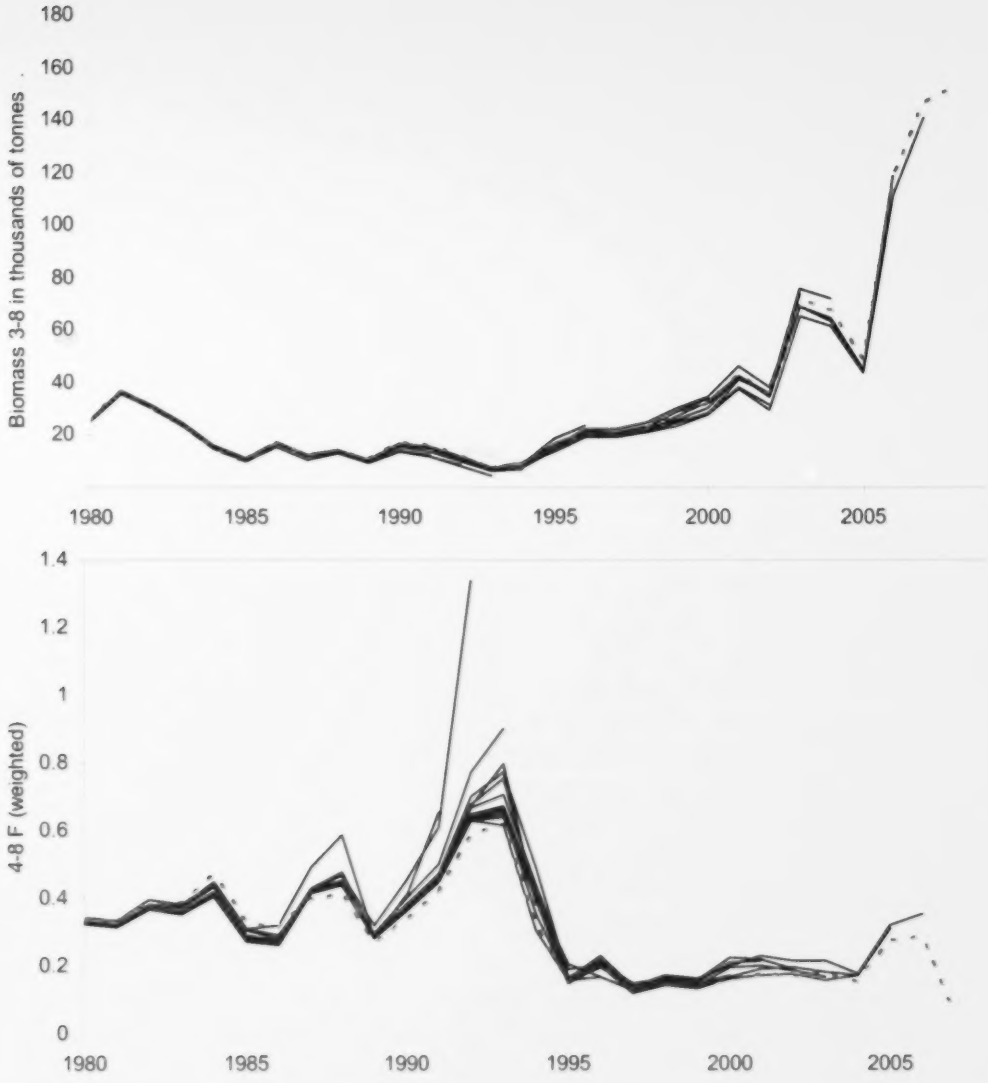


Figure 28. Retrospective estimates from virtual population analysis of eastern Georges Bank haddock biomass and fishing mortality as successive years of data were excluded in the assessment.

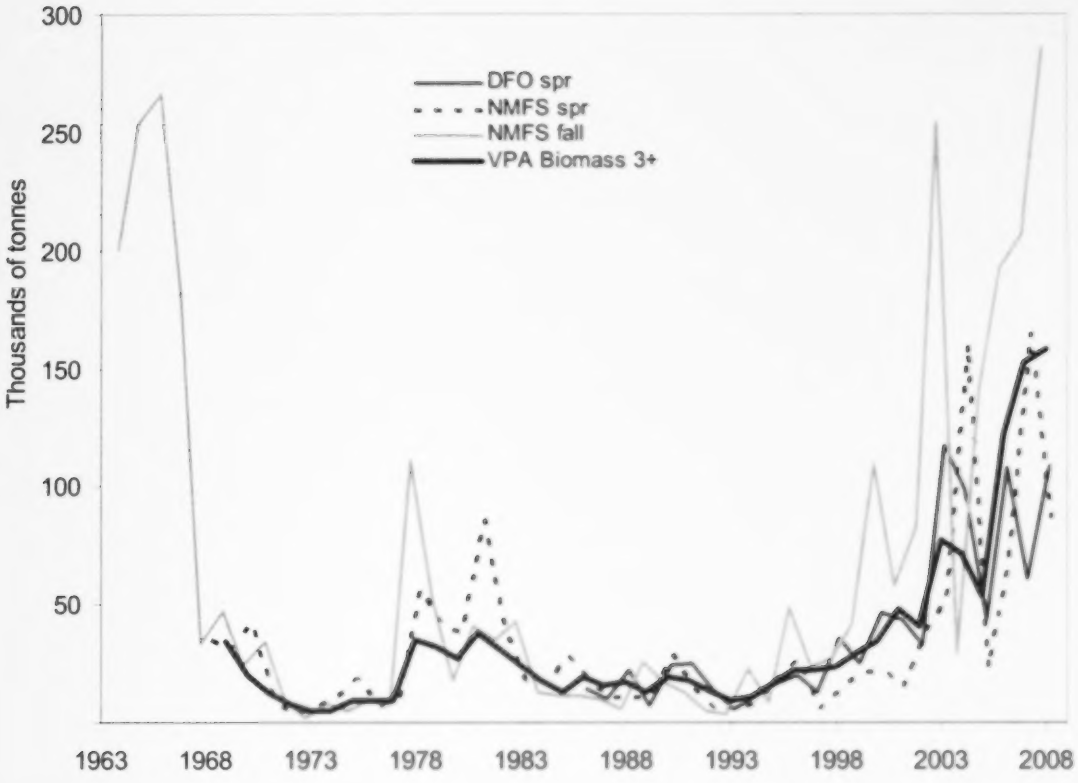


Figure 29. The eastern Georges Bank adult haddock (ages 3+) biomass trend from virtual population analysis compared with the survey adult biomass (scaled with catchabilities) trends.

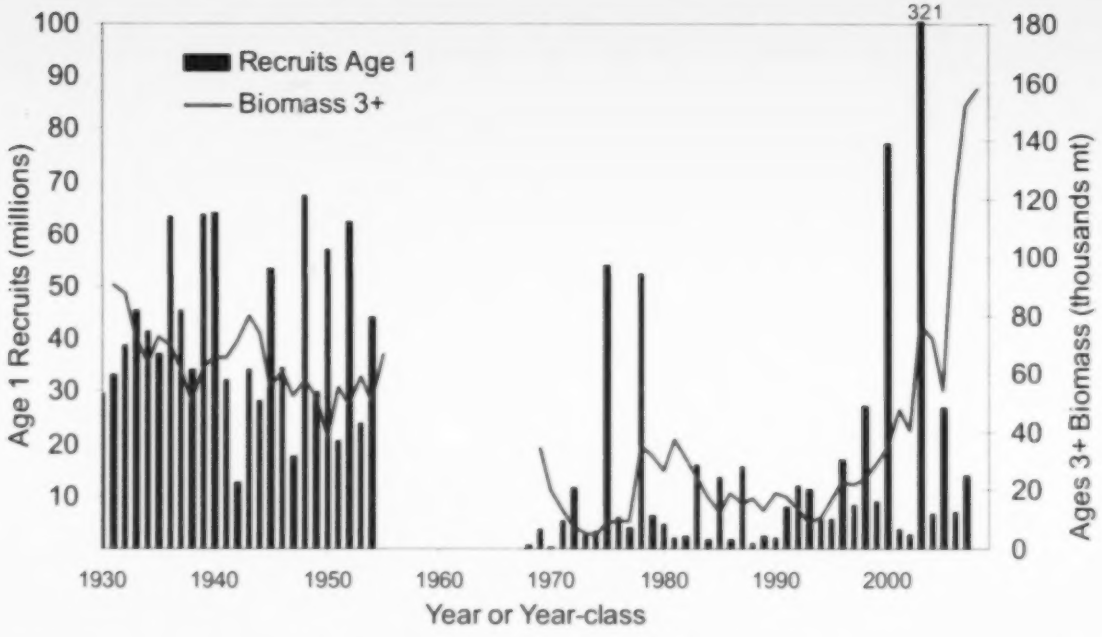


Figure 30. Beginning of year adult (3+) biomass and number of Age 1 recruits for eastern Georges Bank haddock during 1931-1955 and 1969-2008.

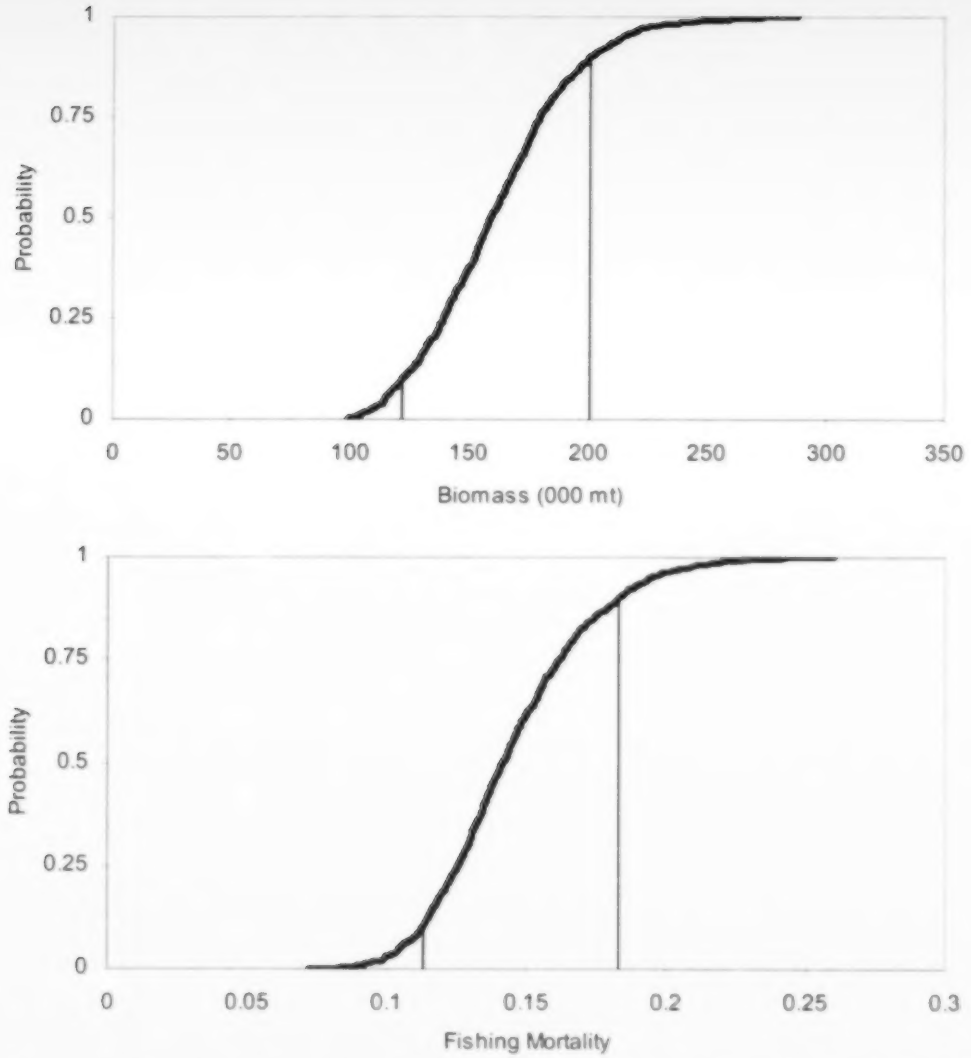


Figure 31. Confidence distribution with 80% confidence intervals for 2008 eastern Georges Bank haddock ages 3+ biomass (000 mt) and 2007 ages 5+ fishing mortality.

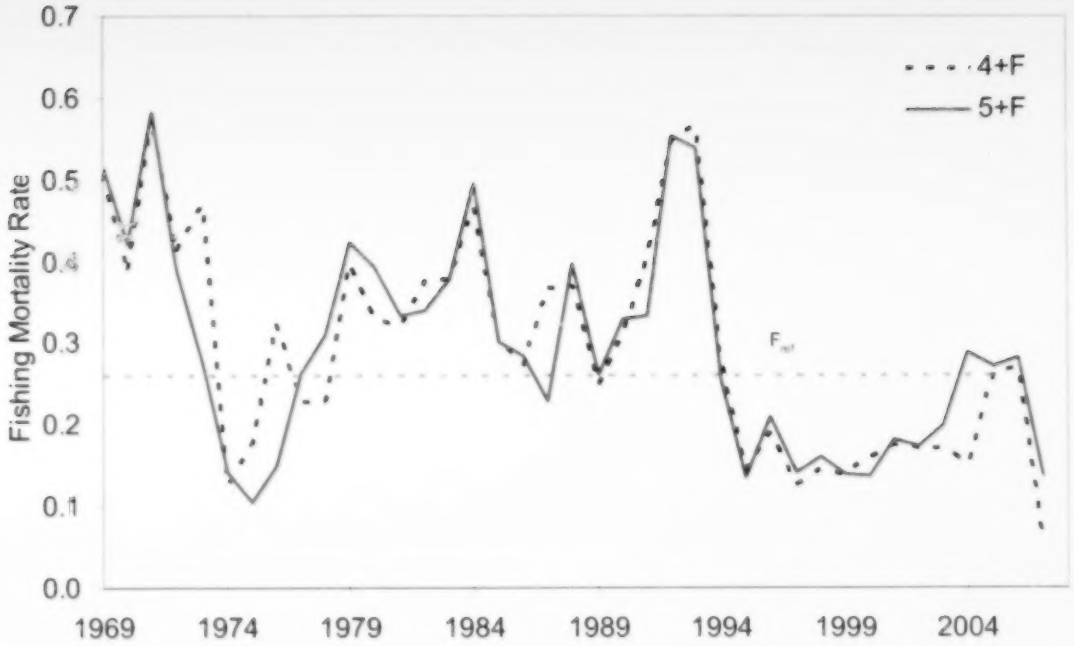


Figure 32. Fishing mortality rate (weighted by population) for eastern Georges Bank haddock ages 4+ and 5+ during 1969-2007 and the fishing mortality threshold reference established at F_{ref} = 0.26.

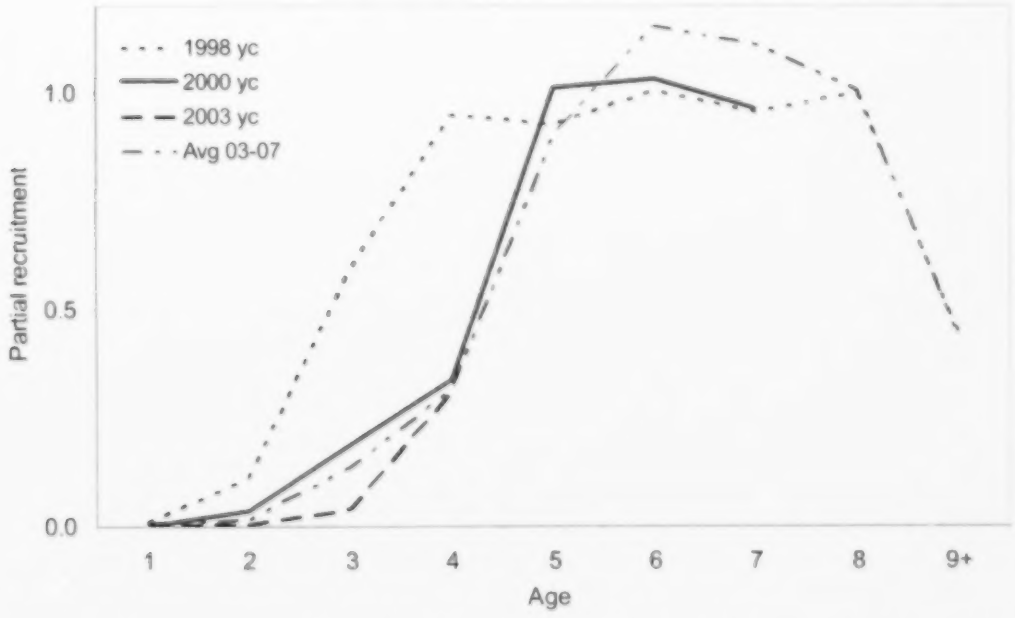


Figure 33. Average partial recruitment of eastern Georges Bank haddock for 3 year classes, 1998, 2000 and 2003 and the average for 2003 to 2007. The partial recruitment is normalized to ages 4-8 for years before 2003 and to ages 5-8 for years after 2002.

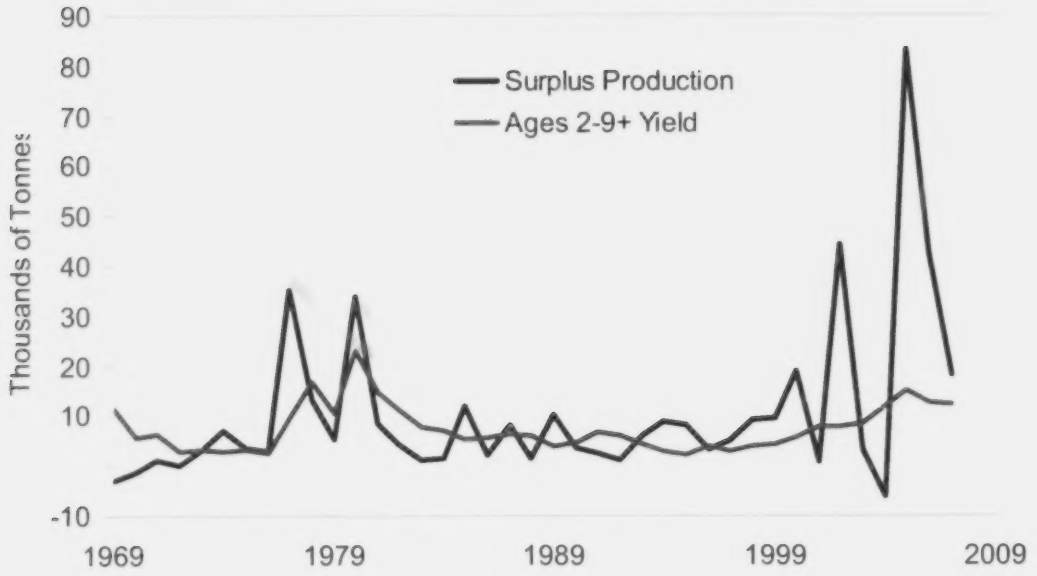


Figure 34. Surplus production of eastern Georges Bank haddock available to the commercial fishery compared to the harvested yield during 1969-2007.

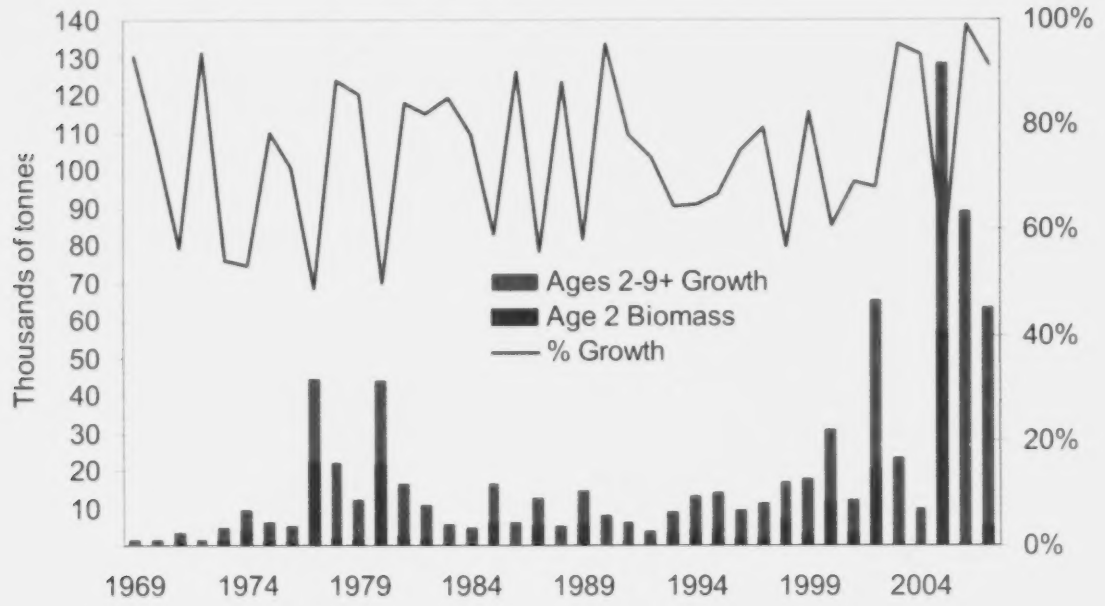


Figure 35. Amount of productivity attributible to growth (ages 2 to 9+) of eastern Georges Bank haddock and the amount contributed by recruitment (Age 2) during 1969-2007.

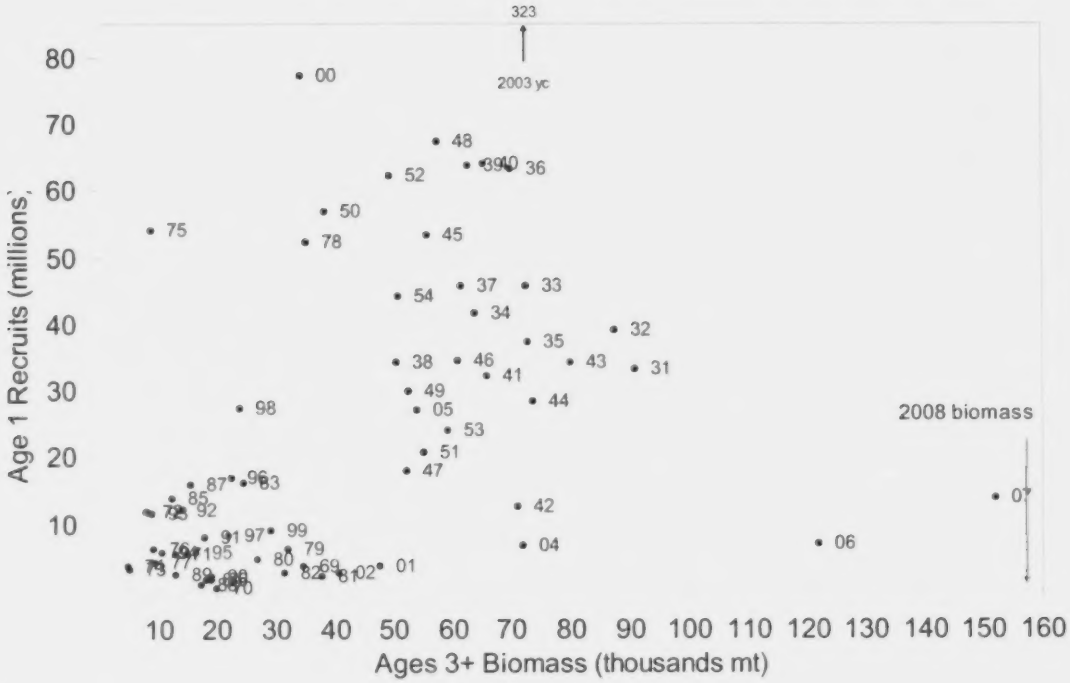


Figure 36. Relationship between eastern Georges Bank adult (ages 3+) haddock biomass and recruits at Age 1 during 1931-1955 and 1969-2007.

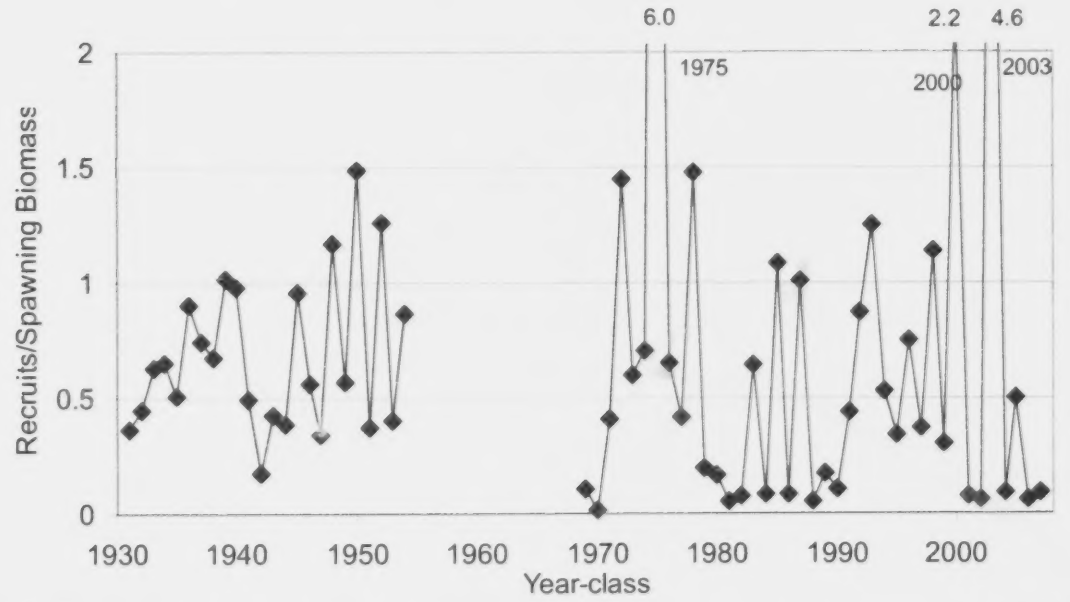


Figure 37. Ratio of recruits (numbers at Age 1) to spawning biomass (kg) for eastern Georges Bank haddock during 1931-1955 and during 1969-2007.

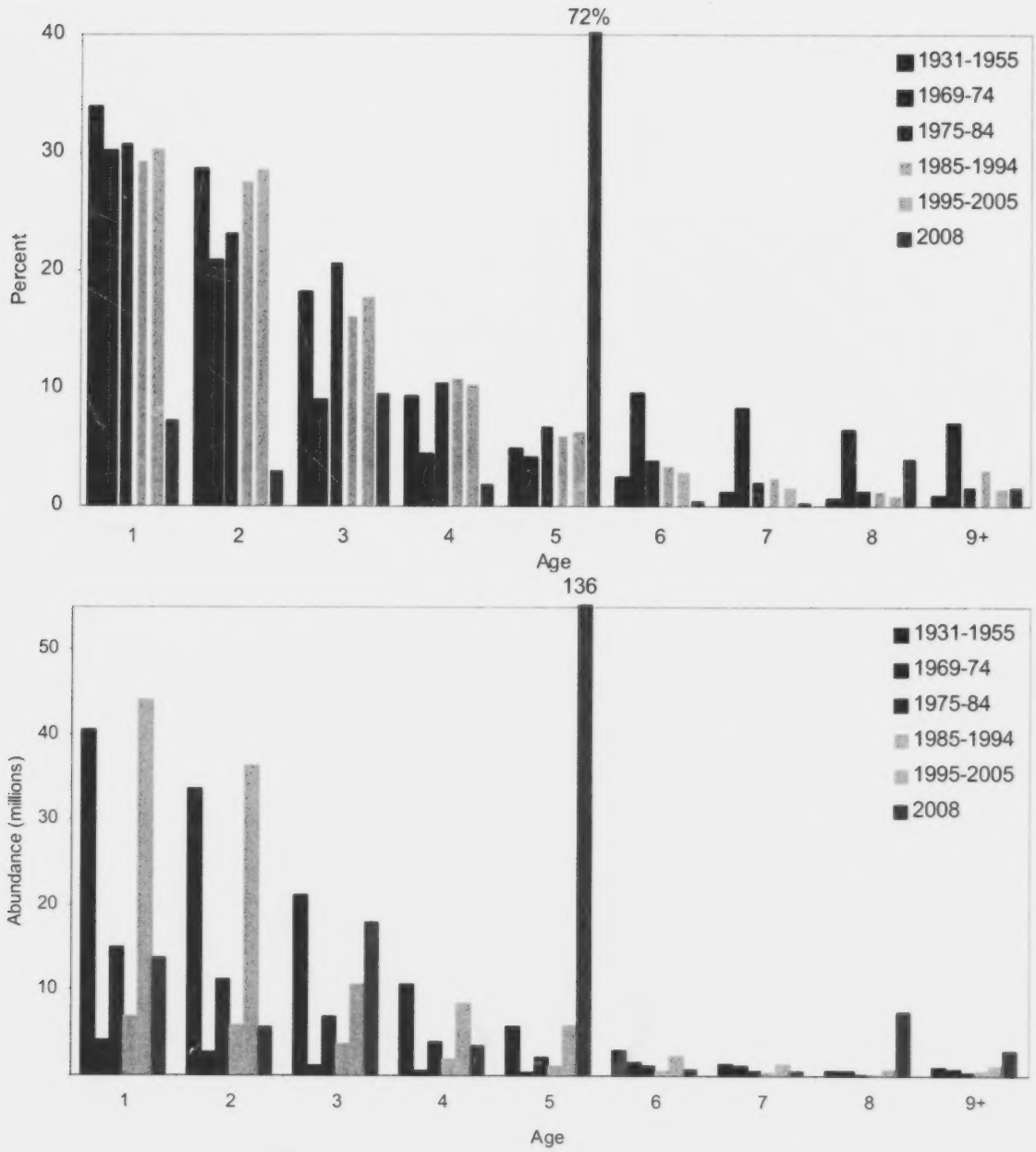


Figure 38. The age composition and absolute abundance at age of the eastern Georges Bank haddock population in 2008 compared to averages during 1931-1955, 1969-1974, 1975-1984, 1985-1994, and 1995-2005.

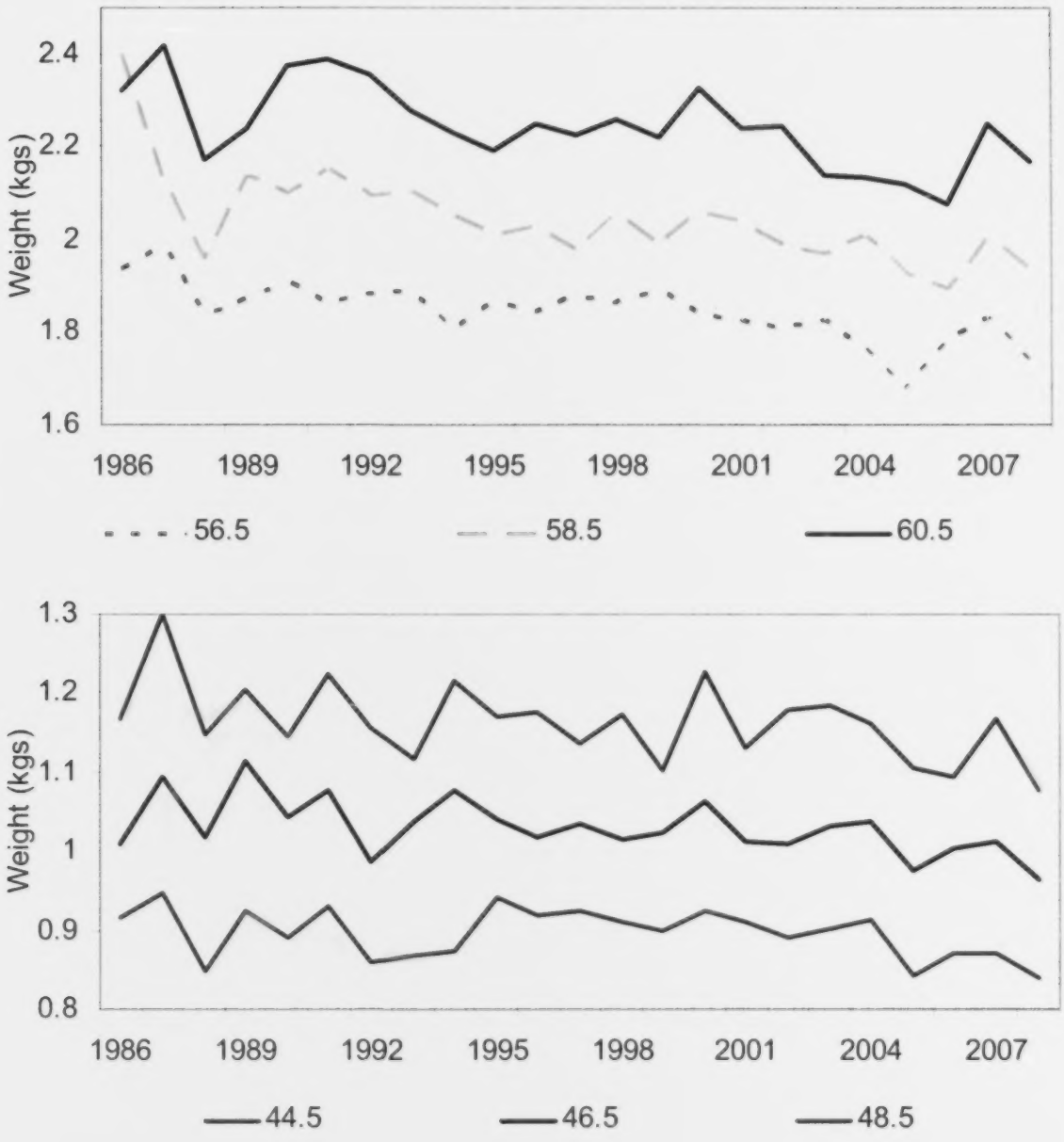


Figure 39. Canadian Department of Fisheries and Oceans survey weights at lengths for eastern Georges Bank haddock for six 2 cm length groupings during 1986-2008.

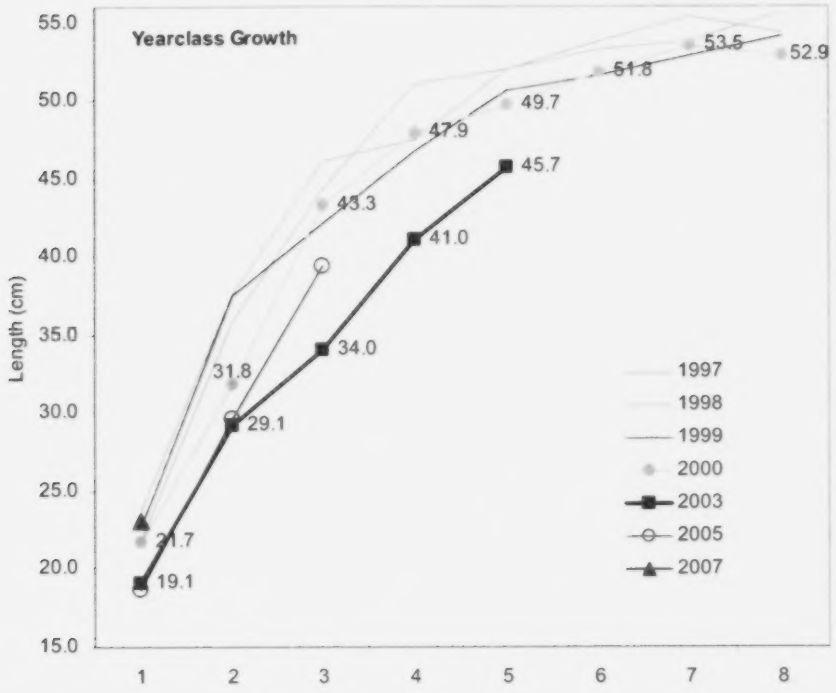


Figure 40. Growth of eastern Georges Bank Georges Bank haddock year classes.

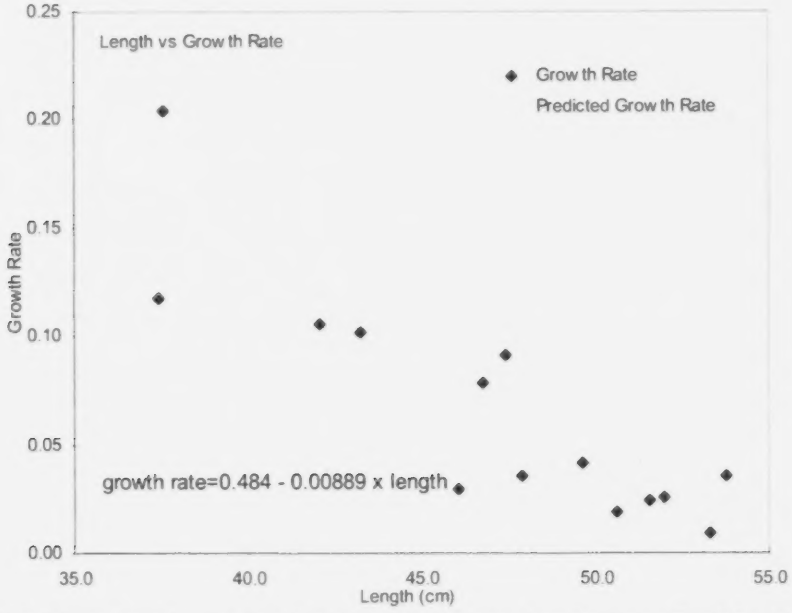


Figure 41. Relationship between length and growth rate derived for eastern Georges Bank haddock using observed growth increments from the 1998, 1999 and 2000 year classes.

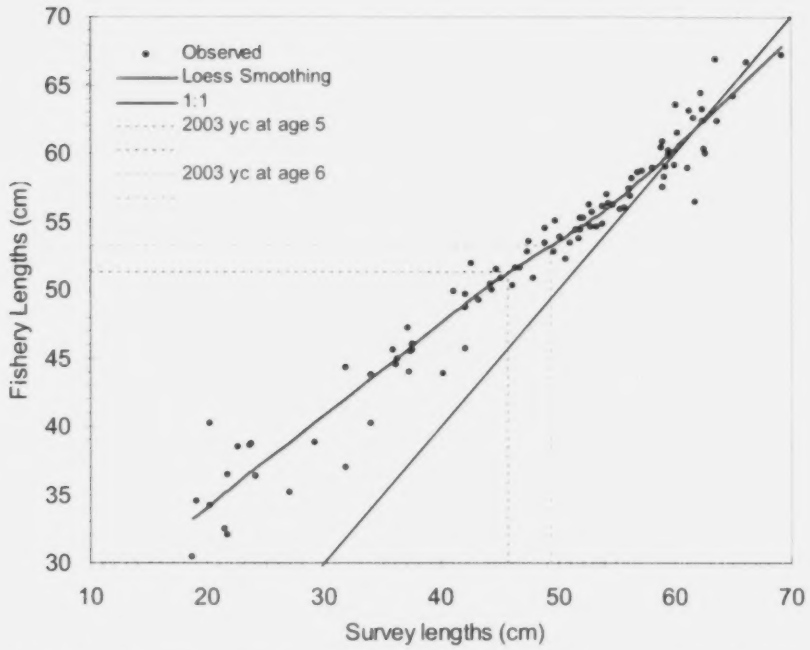


Figure 42. Relationship between eastern Georges Bank haddock beginning of year lengths (from Canadian Department of Fisheries and Oceans surveys) for 1995 to 2006 to average fishery lengths for the same year smoothed with a Loess smoothing algorithm (Clevand 1979). The lengths of the 2003 haddock year class at Age 5 (45.7 cm) and Age 6 (49.4 cm) with the corresponding fishery lengths are indicated. The 1:1 line is added for illustrative purposes.

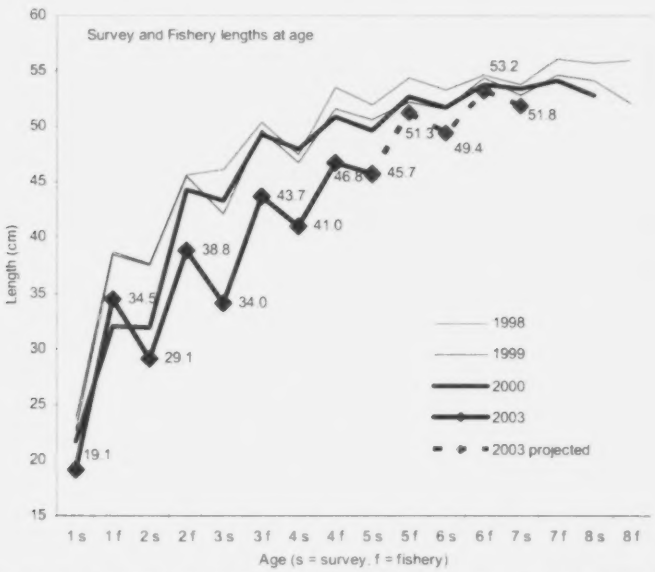


Figure 43. Average population lengths at age and average fishery lengths at age of the 1998, 1999, 2000 and 2003 year classes of eastern Georges Bank haddock as observed from the Canadian Department of Fisheries and Oceans survey. Predicted lengths for the 2003 year class are indicated by ◆.

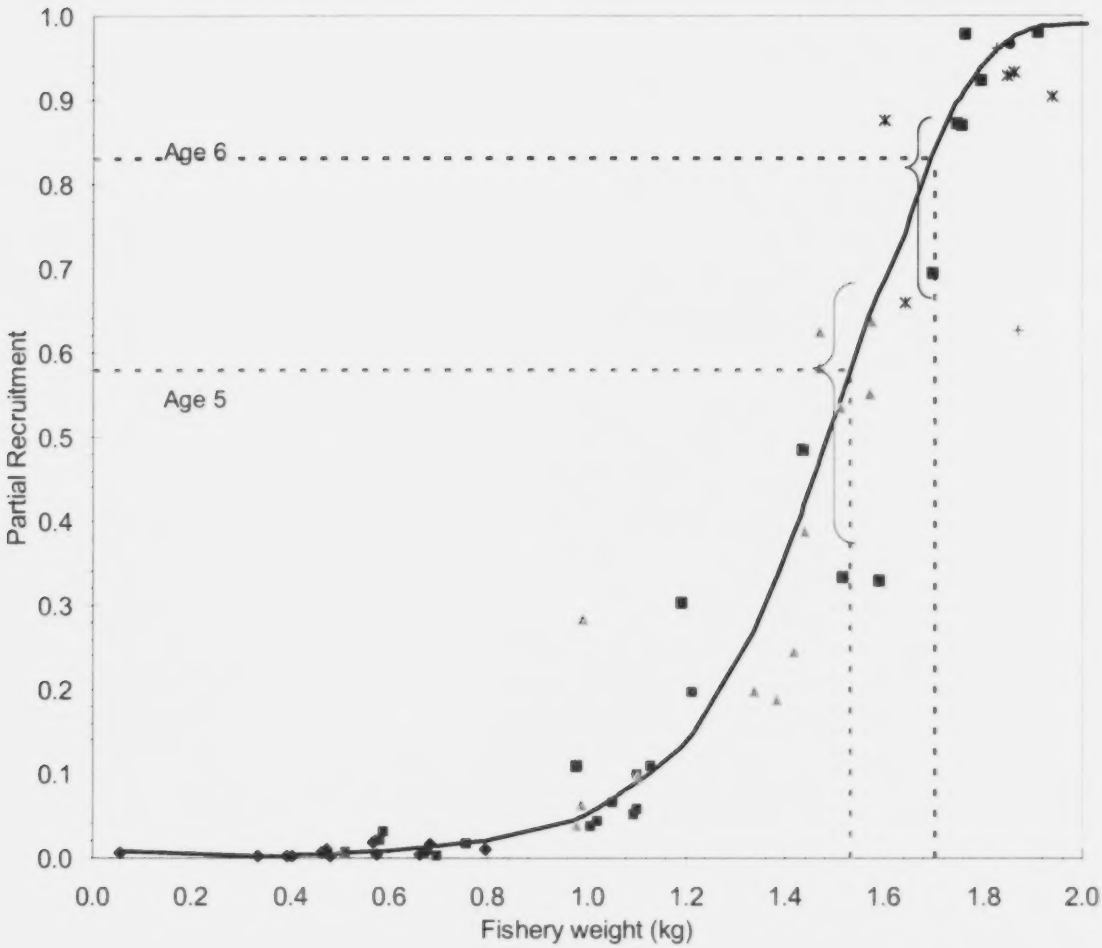


Figure 44. Fishery weight and partial recruitment relationship observed for eastern Georges Bank haddock in 1995 to 2007. A smoothed line was fitted to the data using a loess algorithm (Cleveland 1979). The 2003 year class predicted fishery weight at Age 5 (1.533 kg) and Age 6 (1.705 kg) with the corresponding partial recruitment (0.58 and 0.83, respectively) are indicated by the dotted lines. The gray lines approximate the upper and lower range of partial recruitment values.

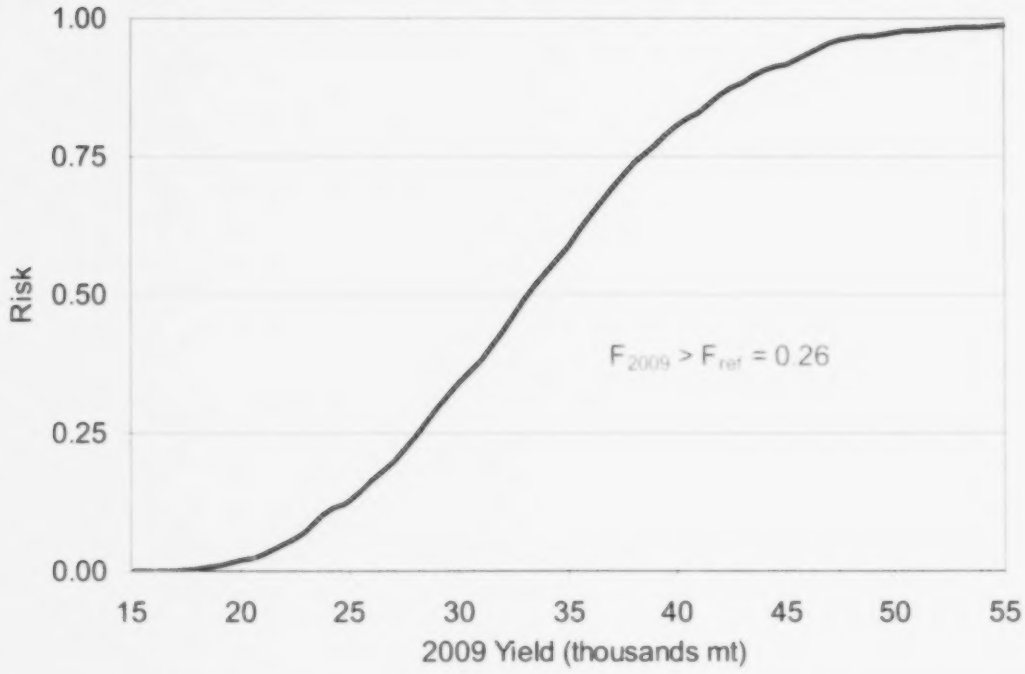


Figure 45. Risk of 2009 fishing mortality exceeding F_{ref} = 0.26 for eastern Georges Bank haddock for increasing catch quotas.

Appendix A. Modifications to ADAPT formulation from that used in previous assessment (2007).

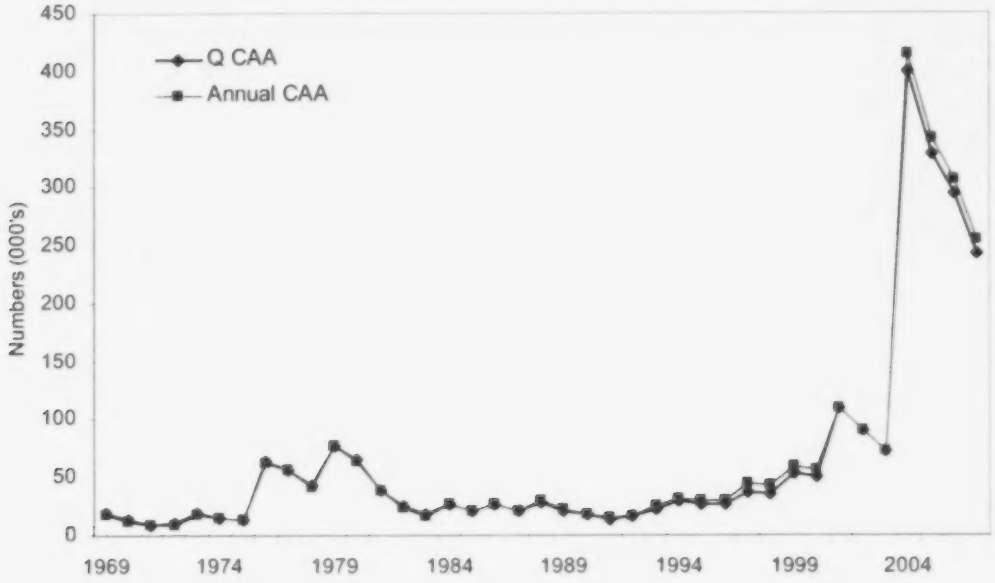


Figure A1. Comparison of eastern Georges Bank haddock population numbers (1+) for ADAPT formulations using a quarterly catch at age (Q CAA) versus an annual catch at age (Annual CAA).

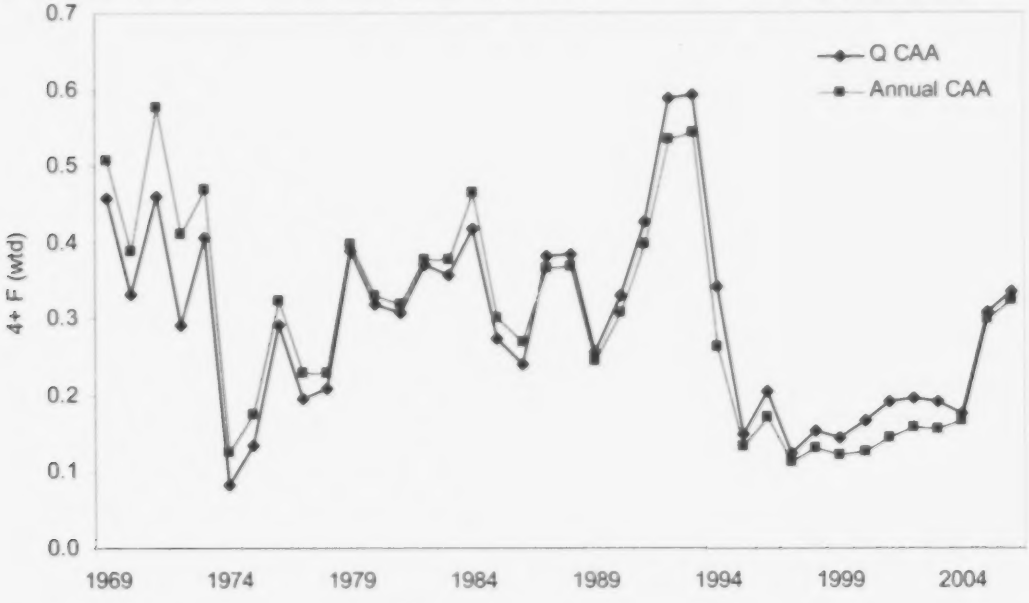


Figure A2. Comparison of 4+ weighted fishing mortality for eastern Georges Bank haddock for ADAPT formulations using a quarterly catch at age (Q CAA) versus an annual catch at age (Annual CAA).

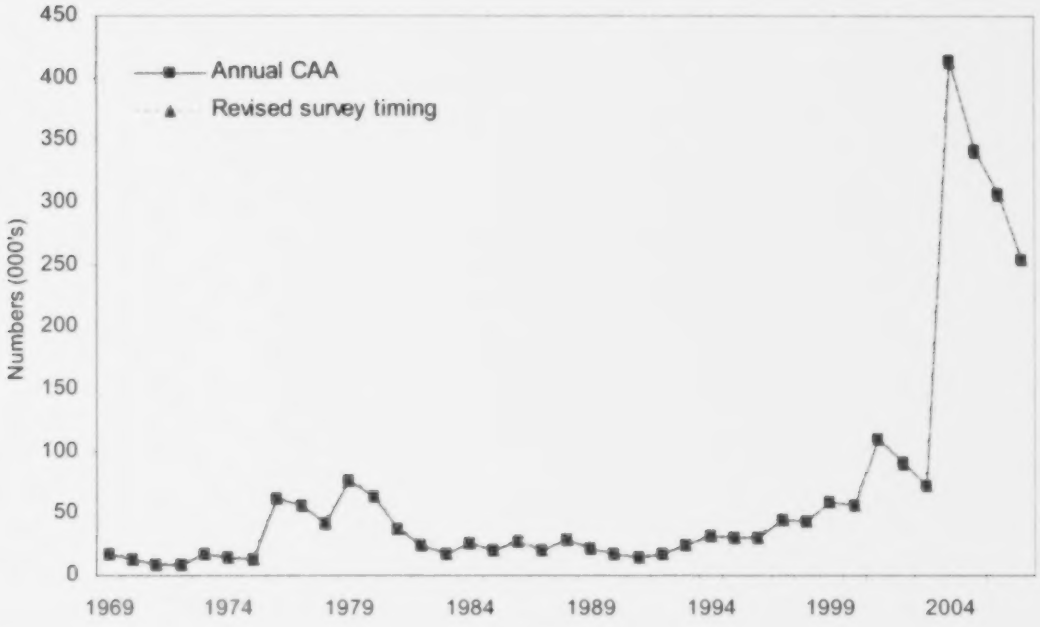


Figure A3. Comparison of eastern Georges Bank haddock population numbers (1+) for ADAPT formulations using an annual catch at age (Annual CAA) versus the same formulation but with revised survey timing.

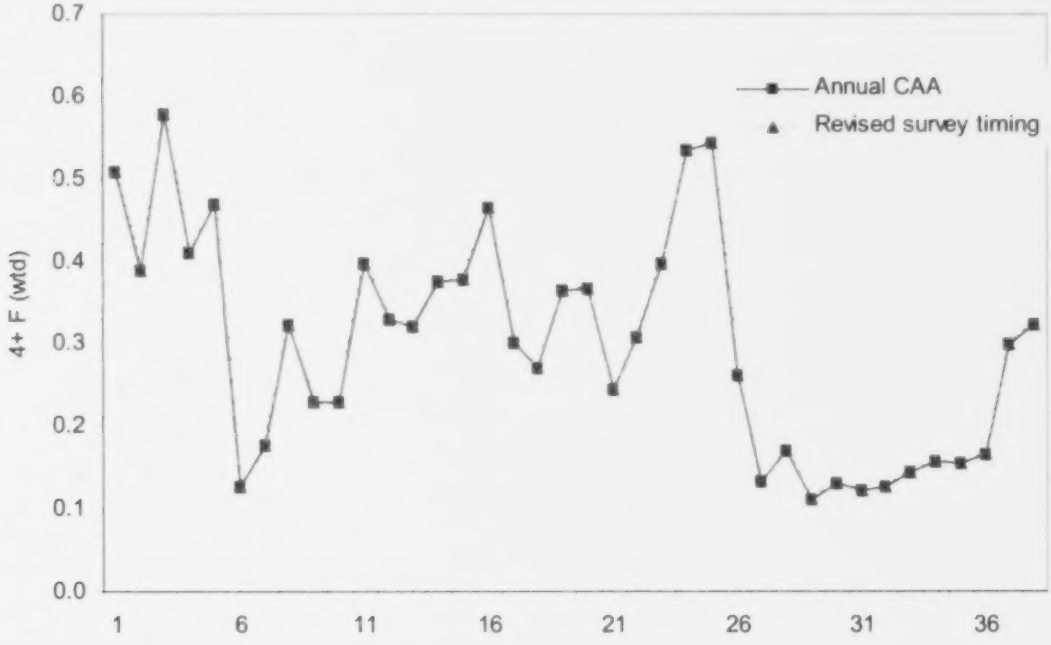


Figure A4. Comparison of eastern Georges Bank haddock 4+ fishing mortality for ADAPT formulations using an annual catch at age (Annual CAA) versus the same formulation but with revised survey timing.